

# Why you can pass tests and *still* fail in the real world



Distinguished McElvain Lecture in Physical Chemistry  
University of Wisconsin Madison  
Madison, WI, 6 May 2014



# Why you can pass tests and *still* fail in the real world



@eric\_mazur

Distinguished McElvain Lecture in Physical Chemistry  
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Madison, WI, 6 May 2014



**kosten**

1. die Kosten (*pl.*)
2. kostbar

455

**krank**

1. die Krankheit, —, —en

**COW**

377

**magnificent**  
**glor**

1. magnificent
2. master

430

**das Kind, —(e)s, —er**

1. kindisch
2. kindlich

**der Kellner, —s, —**

1. der Keller, —s, —

**kennen**

kannte-gekantt *irreg.*

1. kennen-lernen
2. erkennen
3. bekannt
4. d

428

think



kosten

1. die Kosten

2. 1.

think

428

kennen

kannte-gekant

1. kennen-gekant

2. erkennen

3. bekannt

4. d.

Verizon 3G 4:30 PM

Flashcard

23 of 100

pedantic

adj. ostentatious in one's learning

23 of 100

Verizon 3G 4:30 PM

Search

Popular

Subjects

Grade Levels

Standardized

Home

My Books

Review

More

**35 % retained  
after 1 week**

**we only guarantee  
they'll pass the test**





# 5-minute university

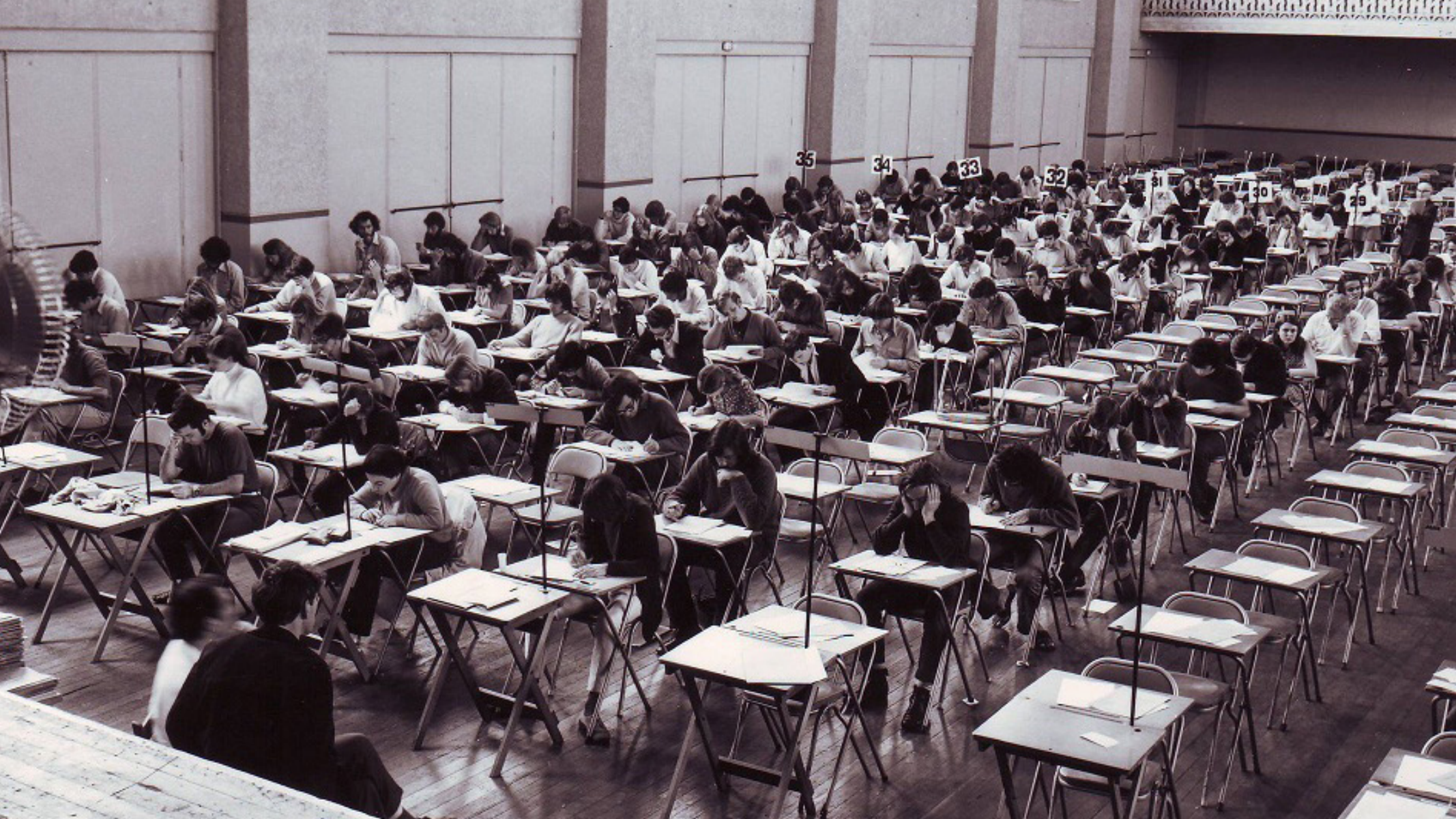












A large, dimly lit classroom filled with students sitting at desks, appearing to be in a test or lecture setting. The students are mostly seen from behind, looking towards the front of the room. The desks are arranged in rows, and the room has a high ceiling with large windows or doors in the background. The overall atmosphere is one of a formal, structured educational environment.

**assessment focussed on ranking and classifying,  
not on developing 21st century skills**



1 purposes



1 purposes

2 problems





1 purposes

2 problems

3 improvements



**how many different purposes  
of assessment can you think of?**

**1** purposes

- 1. rate students**
- 2. rate professor and course**
- 3. motivate students to keep up with work**
- 4. provide feedback on learning to students**
- 5. provide feedback to instructor**
- 6. provide instructional accountability**
- 7. improve teaching and learning**



**1** purposes



**1** purposes

**2** problems



## inauthentic tests

1 purposes

2 problems



**inauthentic problem solving**

**1** purposes

**2** problems

**what is the meaning/definition of...?**

**1** purposes

**2** problems



**problem**

**1** purposes

**2** problems

**problem**

**outcome**

**EDUCACION**

**1** purposes

**2** problems

problem

outcome

**KNOWN**

**1** purposes

**2** problems

problem

solution

outcome

**KNOWN**

1 purposes

2 problems

problem

solution

outcome

UNKNOWNN

KNOWNN

1 purposes

2 problems

problem

solution

outcome

UNKNOWNN  
KNOWNN

problem

1 purposes

2 problems

problem

solution

outcome

UNKNOWN

KNOWN

problem

procedure

KNOWN

1 purposes

2 problems

problem

solution

outcome

UNKNOWN

KNOWN

problem

procedure

answer

KNOWN

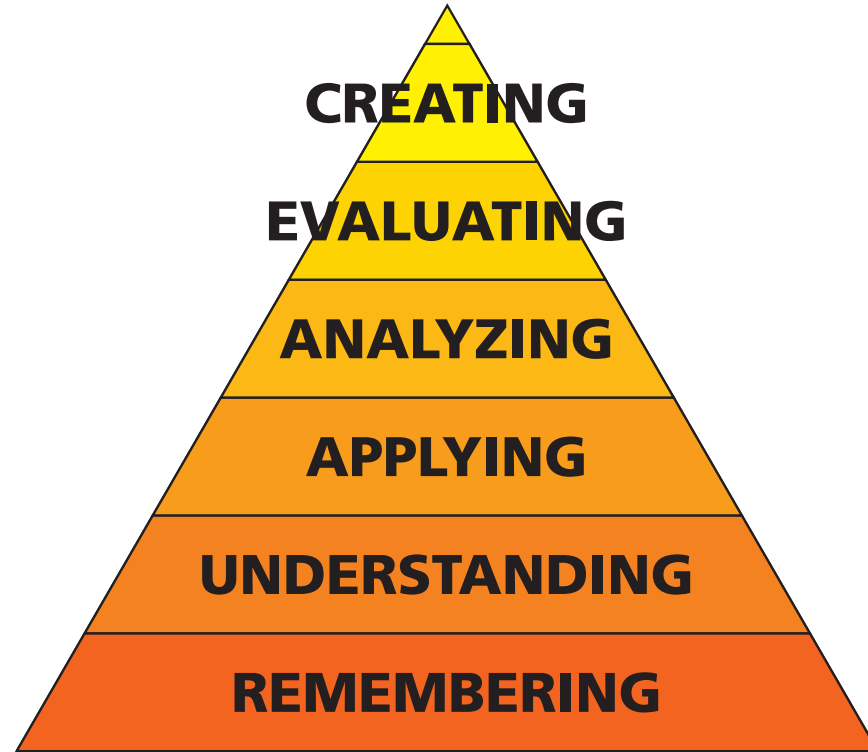
UNKNOWN

1 purposes

2 problems



# Thinking skills



prob

prob

WIN

DOWN

1 purposes

2 problems

**On a Saturday afternoon, you pull into a parking lot with unmetered spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.**

**On a Saturday afternoon, you pull into a parking lot with un-metered spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.**

**How long do you have to wait before someone frees up a space?**

**On a Saturday afternoon, you pull into a parking lot with un-metered spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.**

**How long do you have to wait before someone frees up a space?**

**Requires:**

**Assumptions**

**Developing a model**

**Applying that model**

**On a Saturday afternoon, you pull into a parking lot with un-metered spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.**

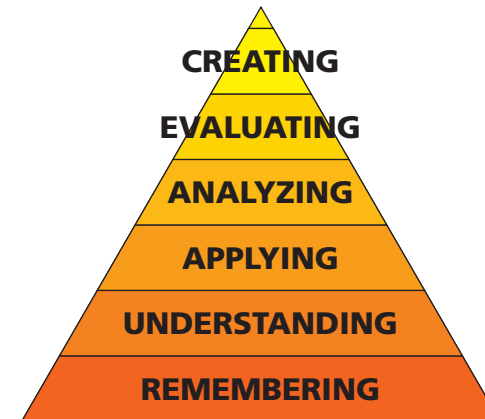
**How long do you have to wait before someone frees up a space?**

**Requires:**

**Assumptions**

**Developing a model**

**Applying that model**



On a Saturday afternoon, you pull into a parking lot with un-metered spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces. **On average people shop for 2 hours.**

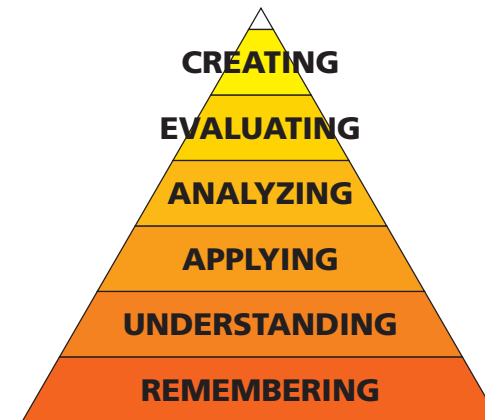
How long do you have to wait before someone frees up a space?

**Requires:**

Assumptions

**Developing a model**

**Applying that model**



On a Saturday afternoon, you pull into a parking lot with un-metered spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces. On average people shop for 2 hours.

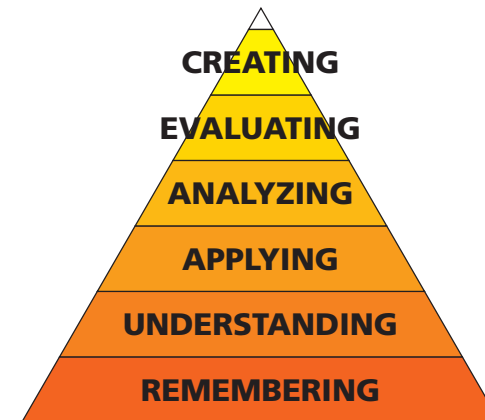
**Assuming people leave at regularly-spaced intervals, how long do you have to wait before someone frees up a space?**

**Requires:**

Assumptions

Developing a model

Applying that model



On a Saturday afternoon, you pull into a parking lot with un-metered spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces. On average people shop for 2 hours.

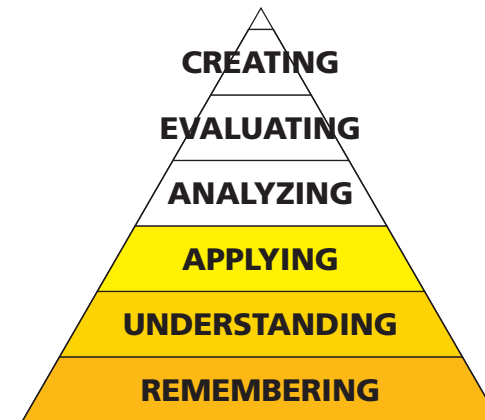
**Assuming people leave at regularly-spaced intervals, how long do you have to wait before someone frees up a space?**

**Requires:**

Assumptions

Developing a model

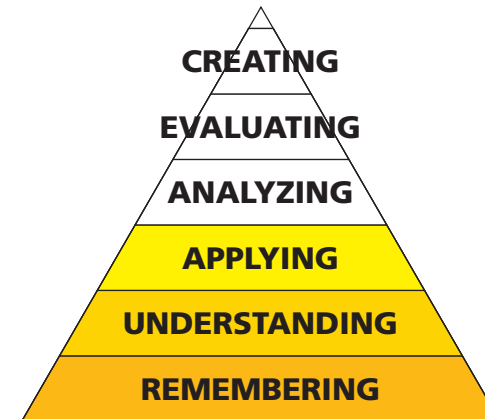
Applying that model





**On a Saturday afternoon, you pull into a parking lot with unmetered spaces near a shopping area, where people are known to shop, on average, for 2 hours. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.**

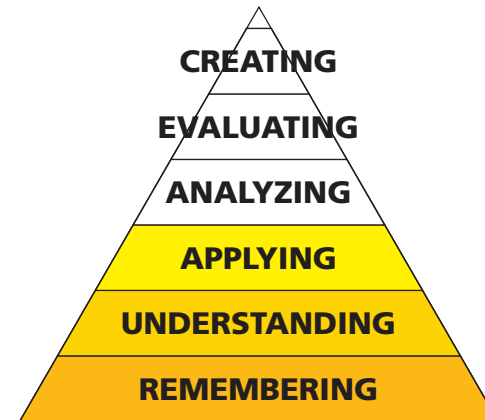
**How long do you have to wait before someone frees up a space?**



On a Saturday afternoon, you pull into a parking lot with unmetered spaces near a shopping area, where people are known to shop, on average, for 2 hours. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.

How long do you have to wait before someone frees up a space?

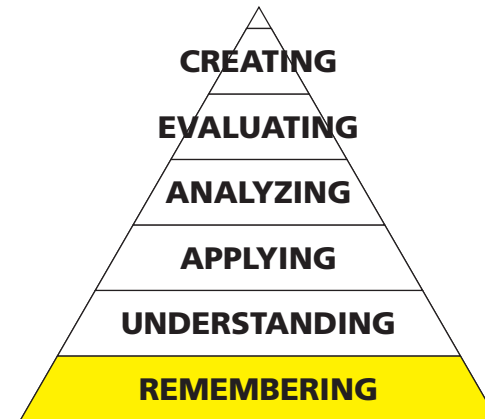
$$t_{wait} = \frac{T_{shop}}{N_{spaces}}$$



On a Saturday afternoon, you pull into a parking lot with unmetered spaces near a shopping area, where people are known to shop, on average, for 2 hours. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.

How long do you have to wait before someone frees up a space?

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



pro

**computers  
can do this!**

outcome

problem

procedure

answer

**KNOWN**

**KNOWN**

**KNOWN**

**UNKNOWN**

**1** purposes

**2** problems



**1** purposes

**2** problems



**1** purposes

**2** problems

problem

solution

outcome

UNKNOWN

KNOWN

problem

problem solving

KNOWN

REAL

1 purposes

2 problems

**problem**

**approach 1**

**approach 3**

**approach 2**

**outcome**

**grading incompatible with real problem solving**

**1 purposes**

**2 problems**





**1** purposes

**2** problems



# isolation

**1** purposes

**2** problems

④ We will use spherical coordinates:

$$0 \leq \rho \leq 4, \quad 0 \leq \theta \leq 2\pi, \quad \frac{\pi}{2} \leq \phi \leq \pi$$

integral is thus:

$$= \left\{ \int_{\rho=0}^4 \rho^3 d\rho \right\} \left\{ \int_{\theta=0}^{2\pi} d\theta \right\} \left\{ \frac{1}{2} \int_{\phi=0}^{\pi} \sin(2\phi) d\phi \right\} = \boxed{0}$$

1 purposes

2 problems

# high-stakes examinations promote cramming



**1** purposes

**2** problems

A person with dark hair is sleeping at a desk. They are holding a pen over an open book. A white mug is on the desk to the left. A pair of glasses is on the desk in front of them. A clock is visible in the bottom left corner of the image. The background is a plain wall.

**information stored in short-term memory**

**1** purposes

**2** problems



**no retention**

information stored in short-term memory

**no transfer**

**1** purposes

**2** problems

grades: measure of standing relative to others

1 purposes

2 problems

**grades: measure of standing relative to others**  
**feedback: reflection on what has been learnt**

**1** purposes

**2** problems



# assessment produces a conflict

1 purposes

2 problems

assessment produces a conflict

coach or judge?

1 purposes

2 problems

conflict resolved by:

objectivity (fairness, reliability)

1 purposes

2 problems

Law Model

Describe the Law of conservation of mass: Sometimes called the Law, states that mass of a closed system will remain constant, regardless of the process. Also, matter cannot be created nor destroyed.

Mass makes me  
happy in humanity

List the three important concepts that the Law of conservation of Energy leads to:

- Equilibrium (boiling)
- Thermodynamics (boiling)
- Kinetics (bow-chicka-wow-wow)

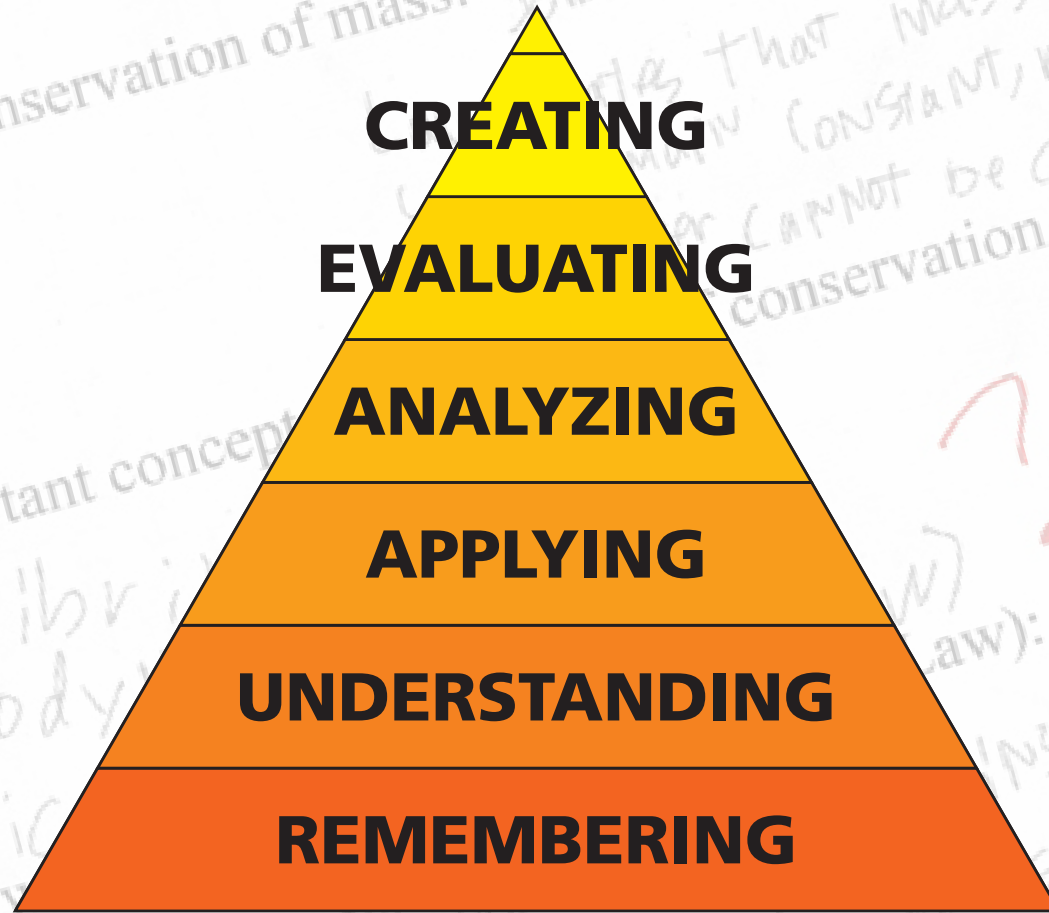
... but ...

Describe the Law of definite composition (Dalton's Law):  
... always contains exactly the same parts by mass.

1 purposes

2 problems

... at a party, Law  
Fri



**1** purposes

**2** problems

**only lowest order thinking skills  
can be judged objectively**

**1** purposes

**2** problems

and then there is...

- grade inflation
- cheating

1 purposes

2 problems



**1** purposes

**2** problems

**3** improvements





**1**

**mimic real life**

**1** purposes

**2** problems

**3** improvements



# open-book exam

**1** purposes

**2** problems

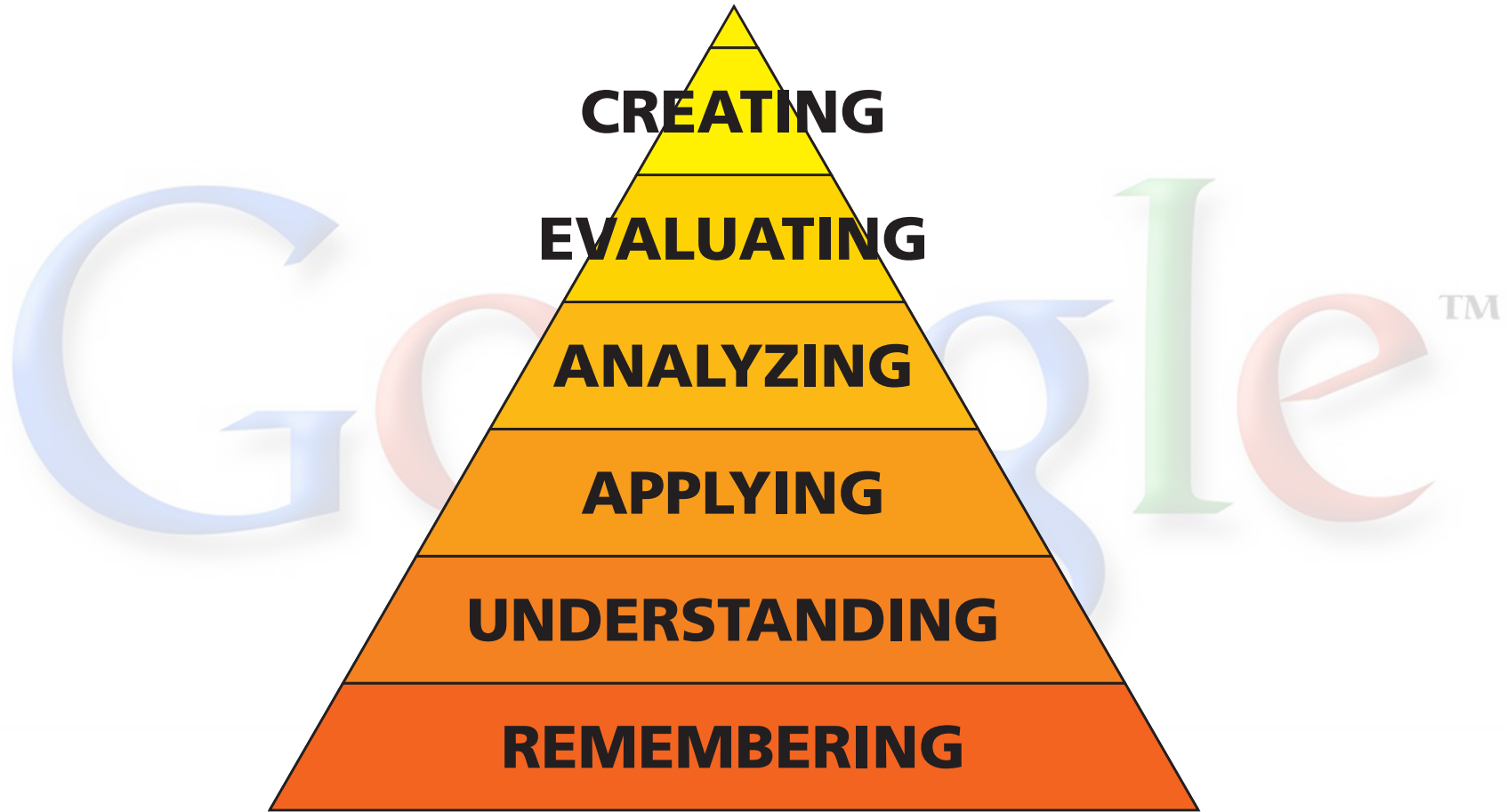
**3** improvements

Google™

1 purposes

2 problems

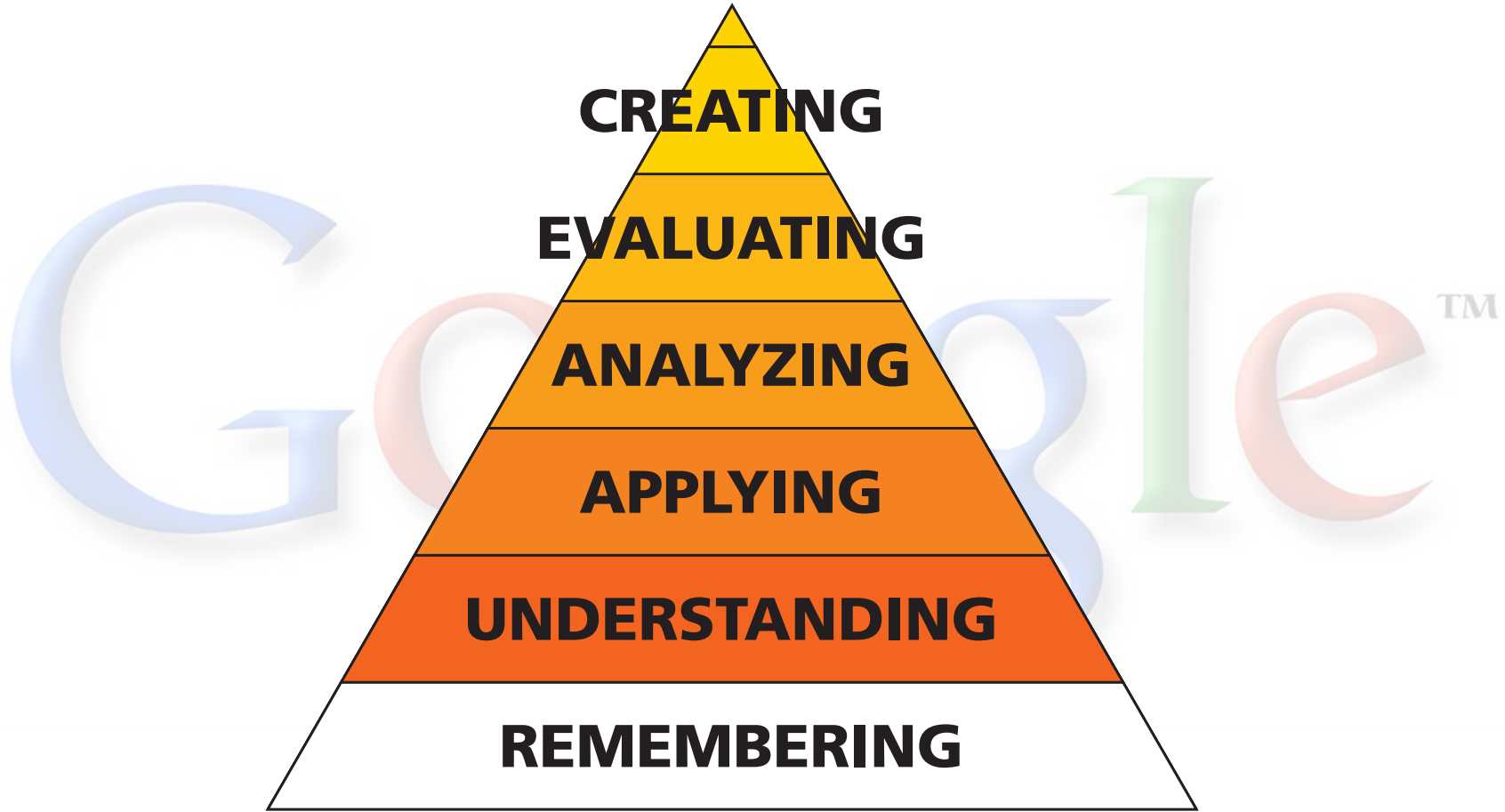
3 improvements



**1** purposes

**2** problems

**3** improvements



**1** purposes

**2** problems

**3** improvements

**1** purposes

**2** problems

**3** improvements

# IMMEDIATE FEEDBACK ASSESSMENT TECHNIQUE (IF AT)

Name Team # 3

Test # 1

Subject \_\_\_\_\_

Total 23

**SCRATCH OFF COVERING TO EXPOSE ANSWER**

|     | A                                   | B                                   | C                                   | D                                   | Score       |
|-----|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------|
| 1.  | <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <u>4</u>    |
| 2.  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <u>2</u>    |
| 3.  | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <u>4</u>    |
| 4.  | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <u>1</u>    |
| 5.  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <u>4</u>    |
| 6.  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <u>4</u>    |
| 7.  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <u>0</u>    |
| 8.  | <input type="checkbox"/>            | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <u>4</u>    |
| 9.  | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <u>    </u> |
| 10. | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <u>    </u> |

**1** purposes

**2** problems

**3** improvements



**1** purposes

**2** problems

**3** improvements



**1** purposes

**2** problems

**3** improvements

## Session 389314

This is the individual round; work on these questions on your own.



Jump to ▼

1

2

3

4

5

### expression question

What is the derivative of  $f(x) = 3x^2 - 6x$ ?

Submit response

Enter an expression, e.g.,  $x^2$  for  $x^2$ ,  $\ln(y) - \sin(x)$  for  $\ln y - \sin x$ ,  $x/(y+1)$  for  $\frac{x}{y+1}$ ,  $(1/2)x$  for  $\frac{1}{2}x$ . Do not enter a complete equation.

Current team: **Blue team**  [Change team](#)

 [Change seat](#)

 [Send a message to the instructor](#)

 [Join another](#)

1 purposes

2 problems

3 improvements

This is the individual round;

**expression question**

What is the derivative of  $f(x) = 3x^2 - 6x$ ?

Submit response

Enter an expression, e.g.,  $x^2$  for  $x^2$ ,  $\ln(y) - \sin(x)$  for  $\ln y - \sin$

1 purposes

2 problems

3 improvements

This is the individual round;

### expression question

What is the derivative of  $f(x) = 3x^2 - 6x$ ?

Submit response

Enter an expression, e.g.,  $x^2$  for  $x^2$ ,  $\ln(y) - \sin(x)$  for  $\ln y - \sin x$

1 purposes

2 problems

3 improvements

$6x - 6$

Brian Lukoff

$6x$

Brent Jones

$6x - 6$

Beth Sawyer

$6x^2 - 6$

Kip Harmon

### expression question

What is the derivative of  $f(x) = 3x^2 - 6x$ ?

Submit response

Enter an expression, e.g.,  $x^2$  for  $x^2$ ,  $\ln(y) - \sin(x)$  for  $\ln y - \sin$

1 purposes

2 problems

3 improvements

**1** purposes

**2** problems

**3** improvements



**2**

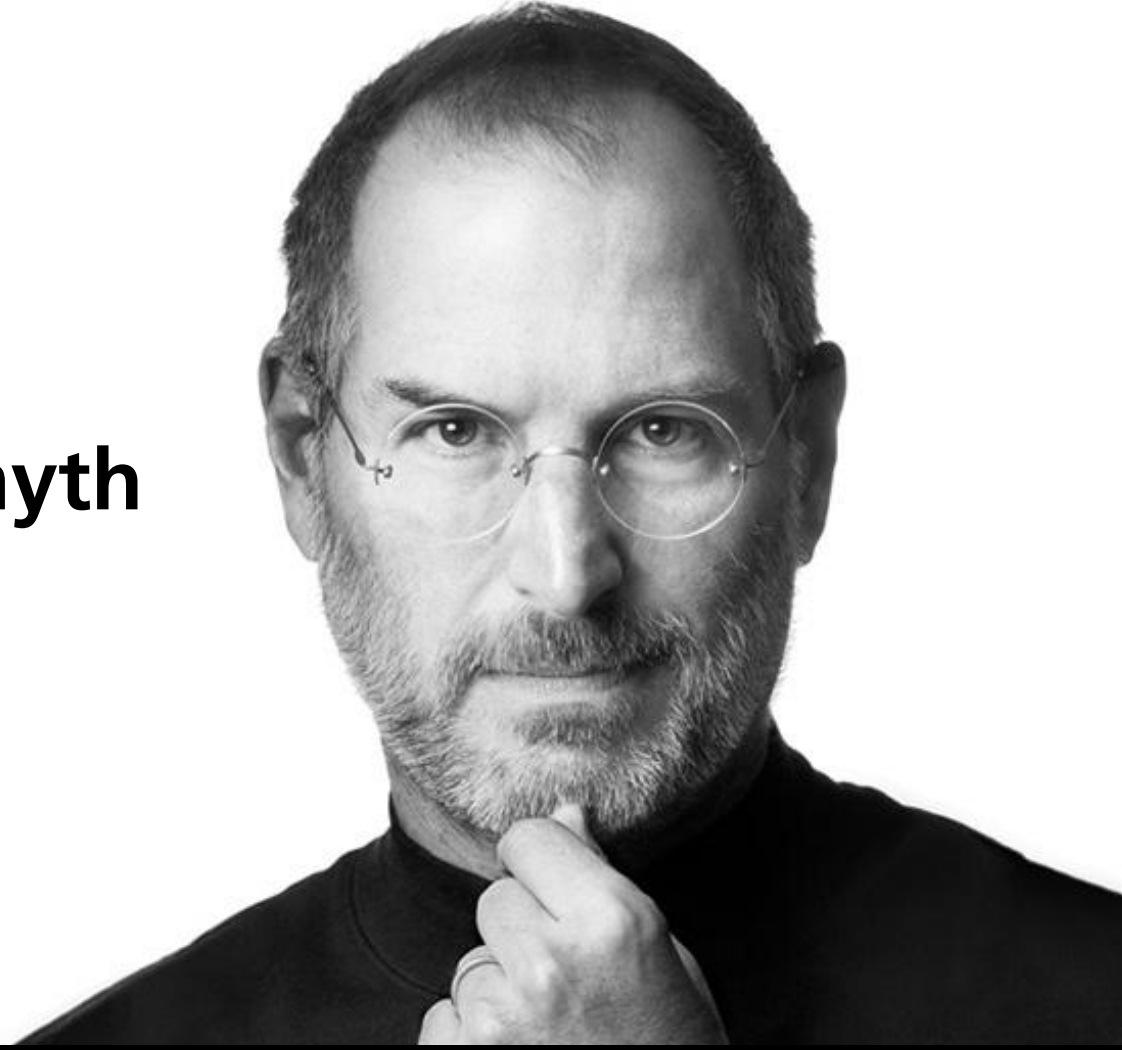
**focus on feedback, not ranking**

**1** purposes

**2** problems

**3** improvements

# objective ranking: a myth



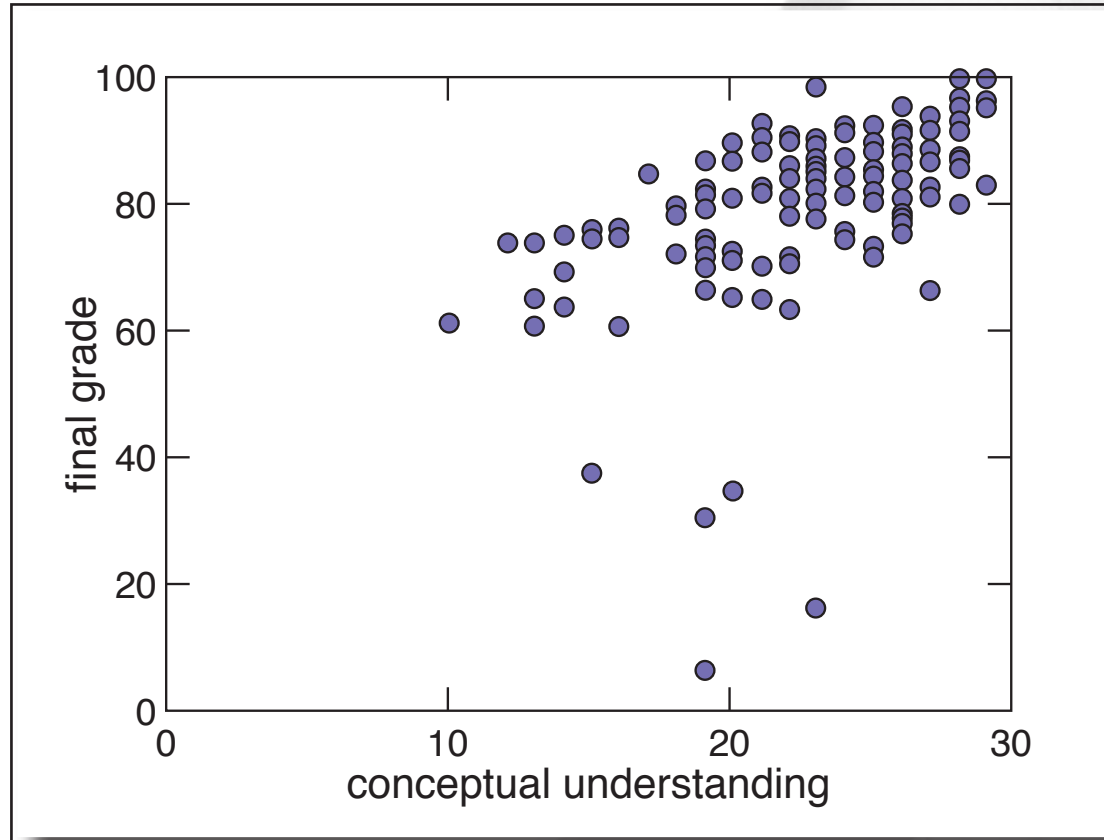
**1** purposes

**2** problems

**3** improvements



# 2 metrics, 2 results

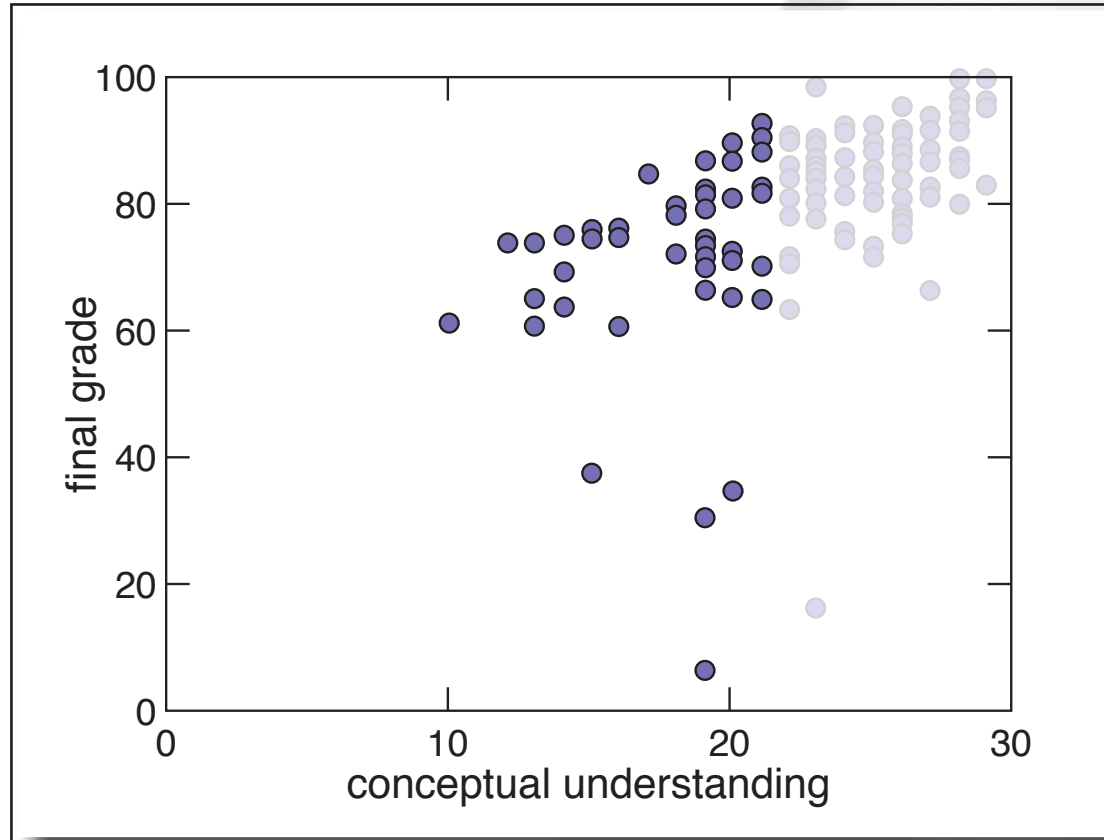


1 purposes

2 problems

3 improvements

# Aristotelian thinkers

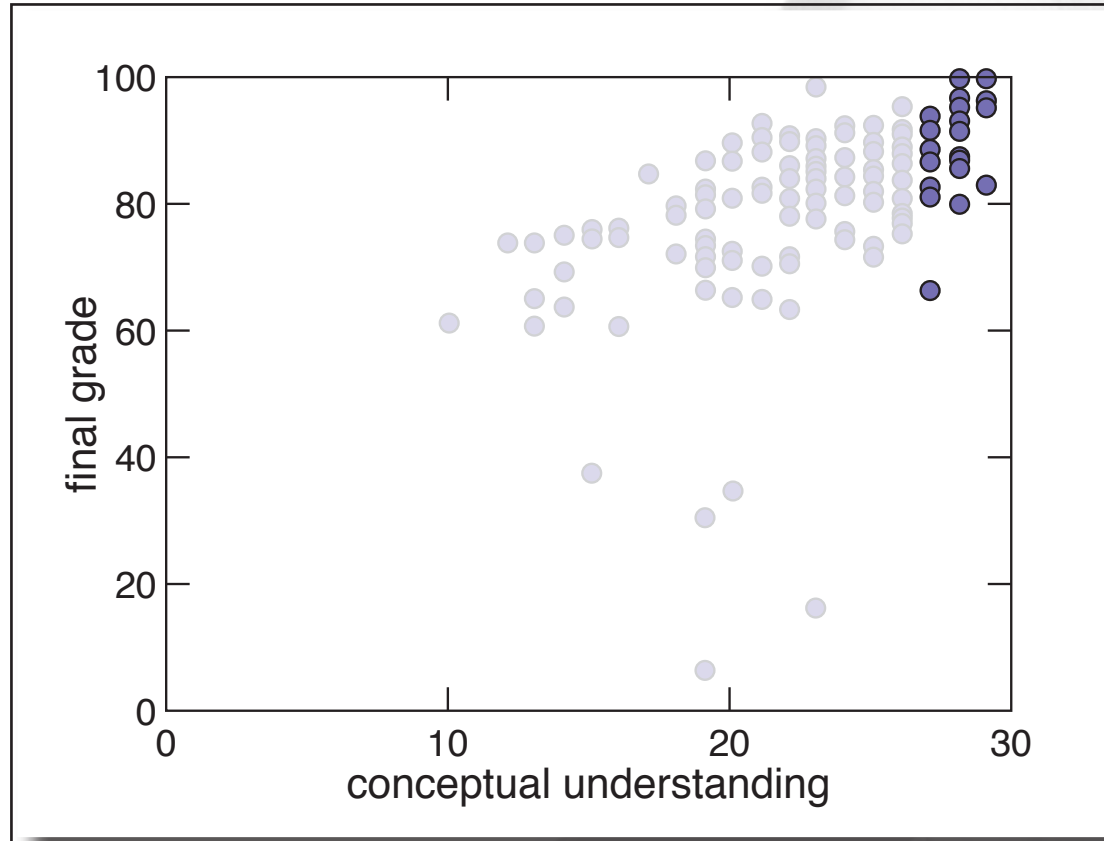


1 purposes

2 problems

3 improvements

# top performers, broad grade distribution

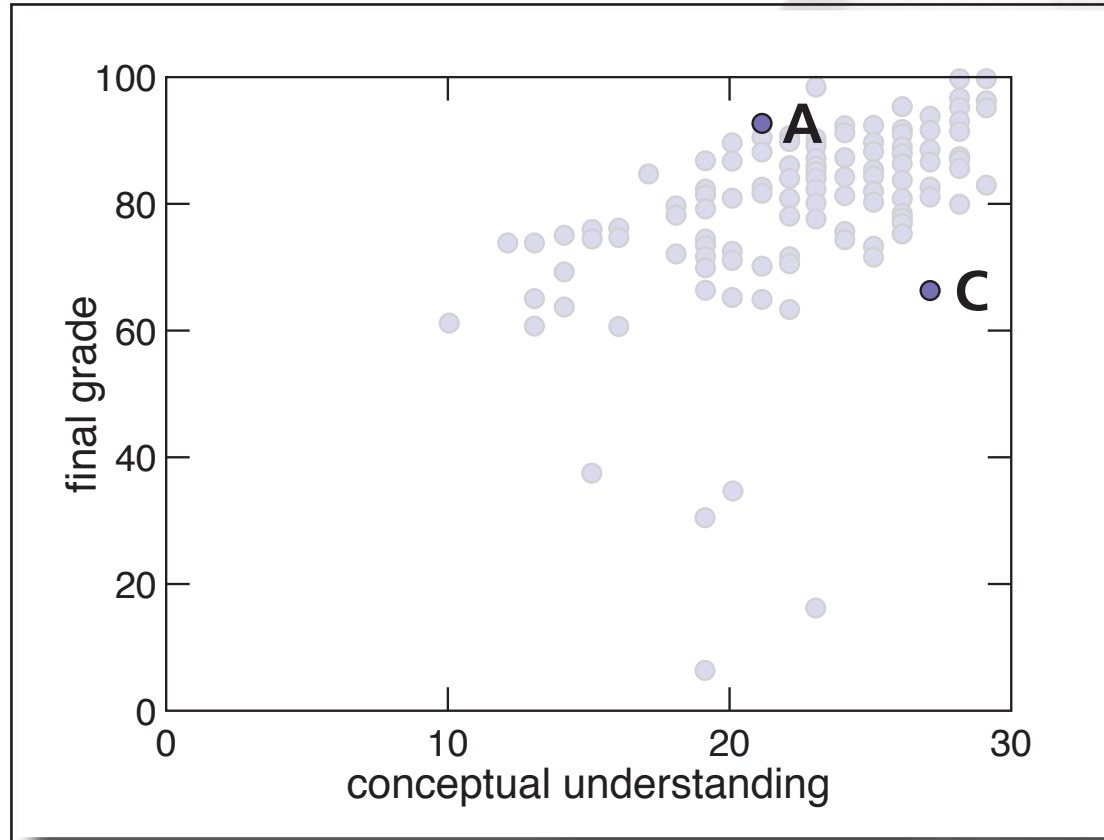


1 purposes

2 problems

3 improvements

# objectivity or injustice?



1 purposes

2 problems

3 improvements



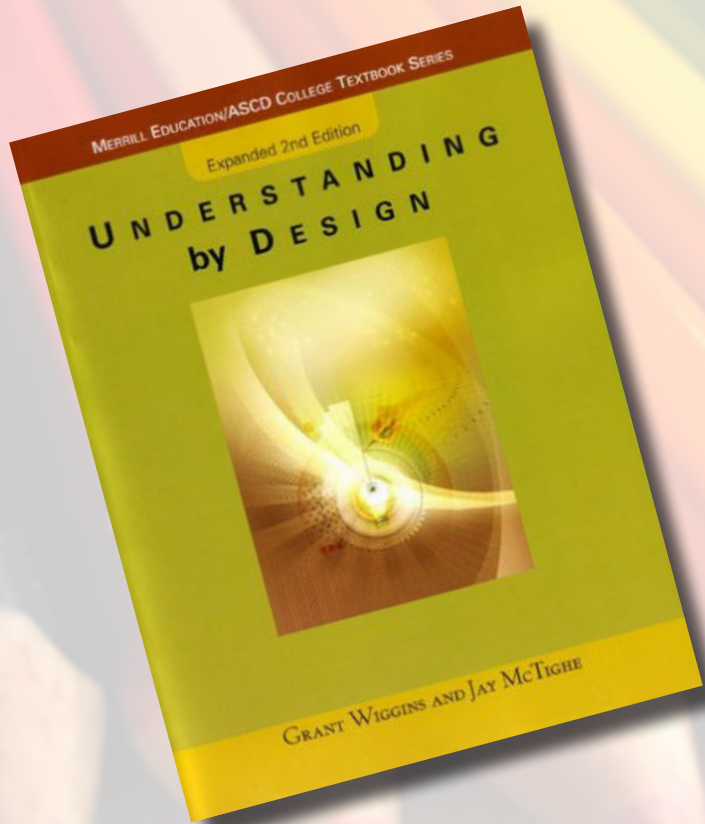
**3**

**focus on skills, not content**

**1** purposes

**2** problems

**3** improvements



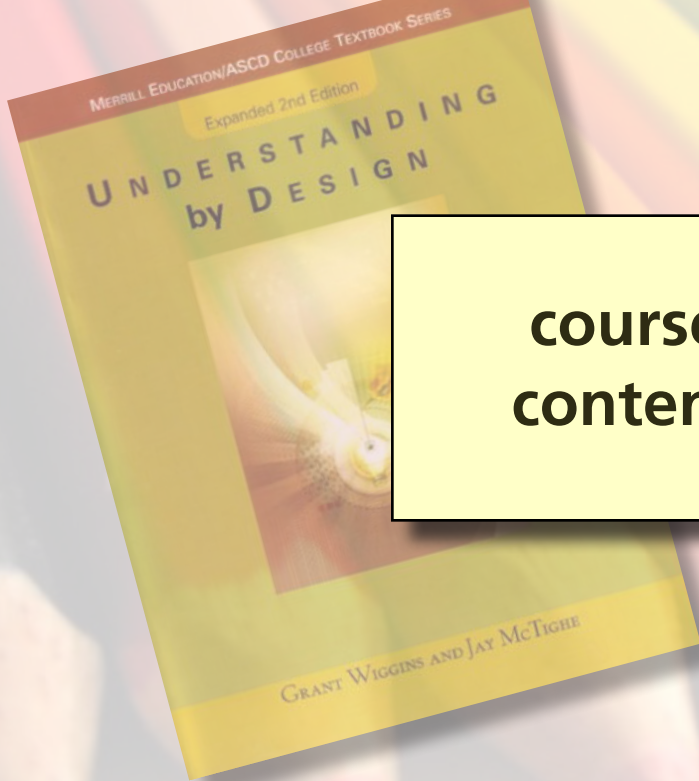
Grant Wiggins and Jay McTighe, *Understanding by Design* (Prentice Hall, 2001)

**1** purposes

**2** problems

**3** improvements

# Traditional approach to course planning



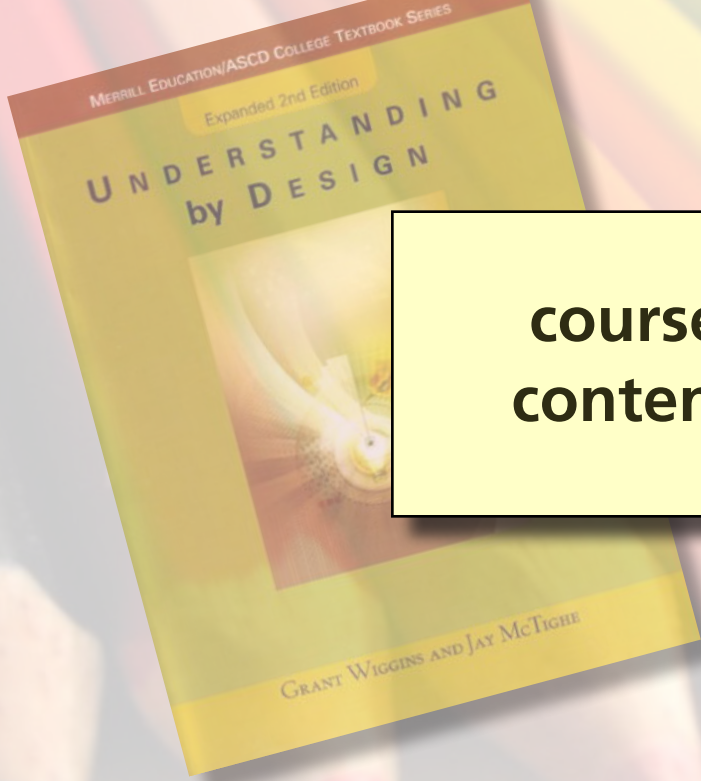
**course  
content**

**1** purposes

**2** problems

**3** improvements

# Traditional approach to course planning



**course  
content**



**assessment**

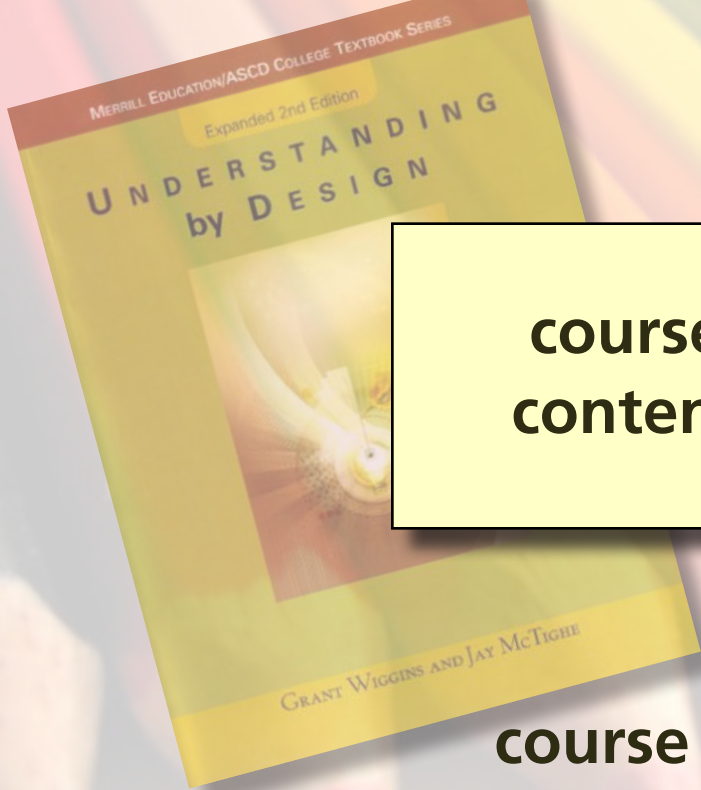
**1** purposes

**2** problems

**3** improvements



# Traditional approach to course planning



**course  
content**



**assessment**

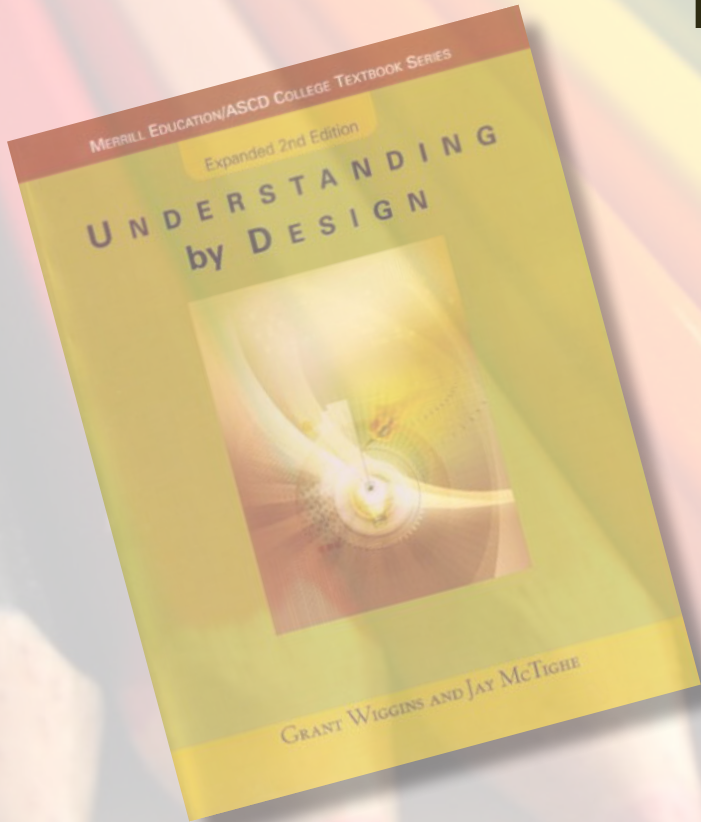
**course determined by content**

**1 purposes**

**2 problems**

**3 improvements**

# Backward design



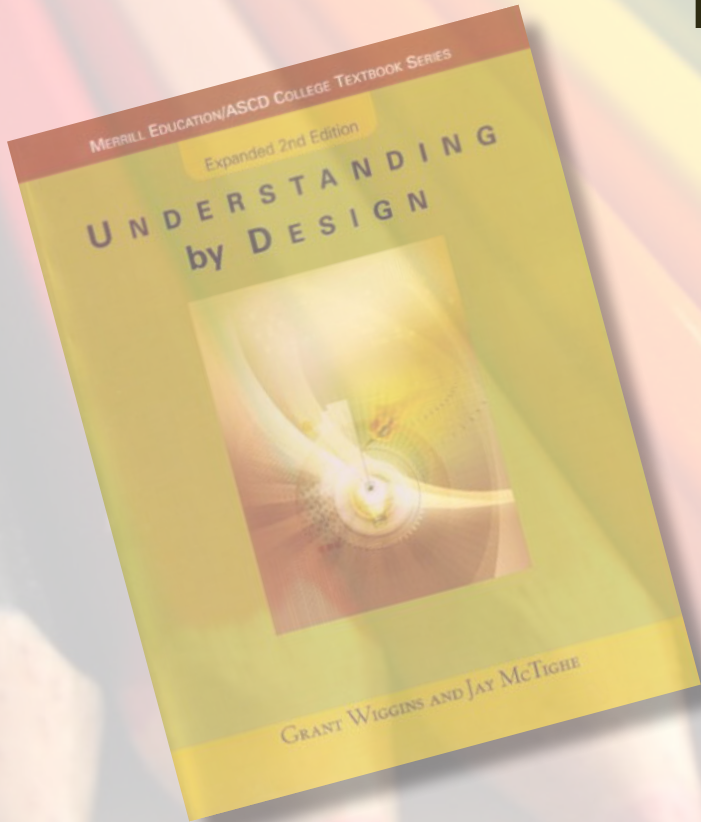
**desired  
outcomes**

**1** purposes

**2** problems

**3** improvements

# Backward design



acceptable  
evidence



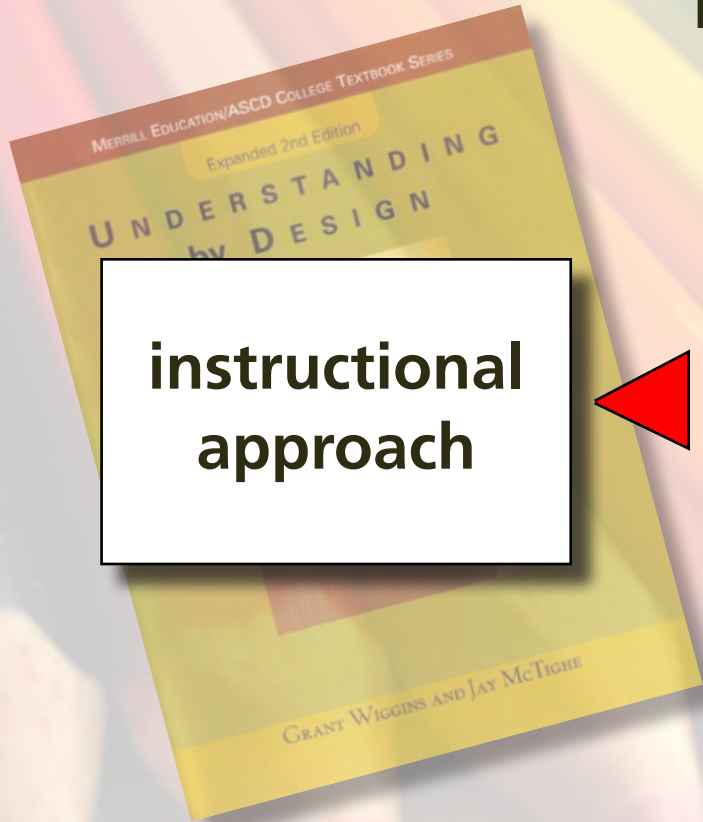
desired  
outcomes

**1** purposes

**2** problems

**3** improvements

# Backward design



**instructional  
approach**



**acceptable  
evidence**



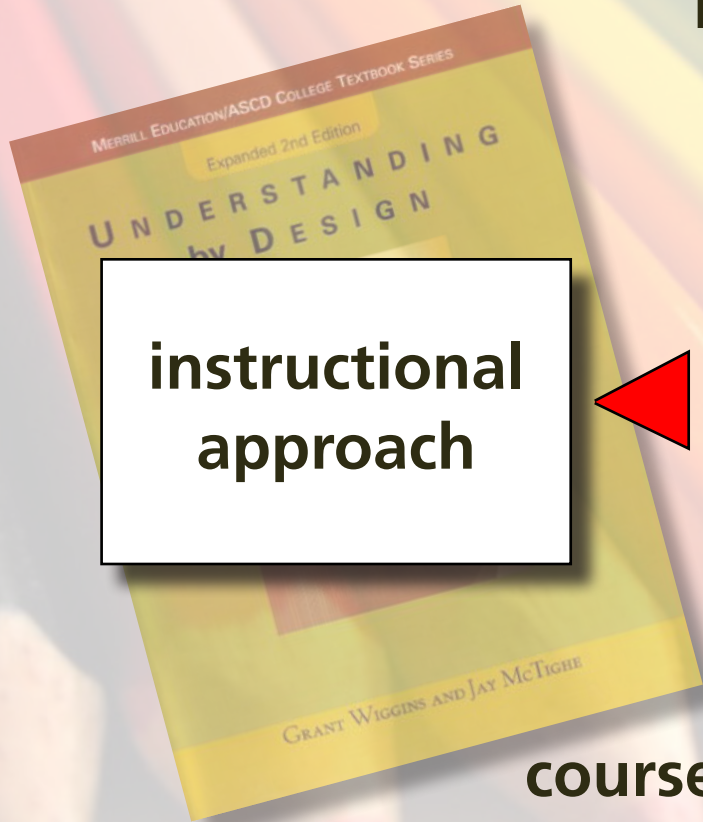
**desired  
outcomes**

**1 purposes**

**2 problems**

**3 improvements**

# Backward design



**instructional  
approach**



**acceptable  
evidence**



**desired  
outcomes**

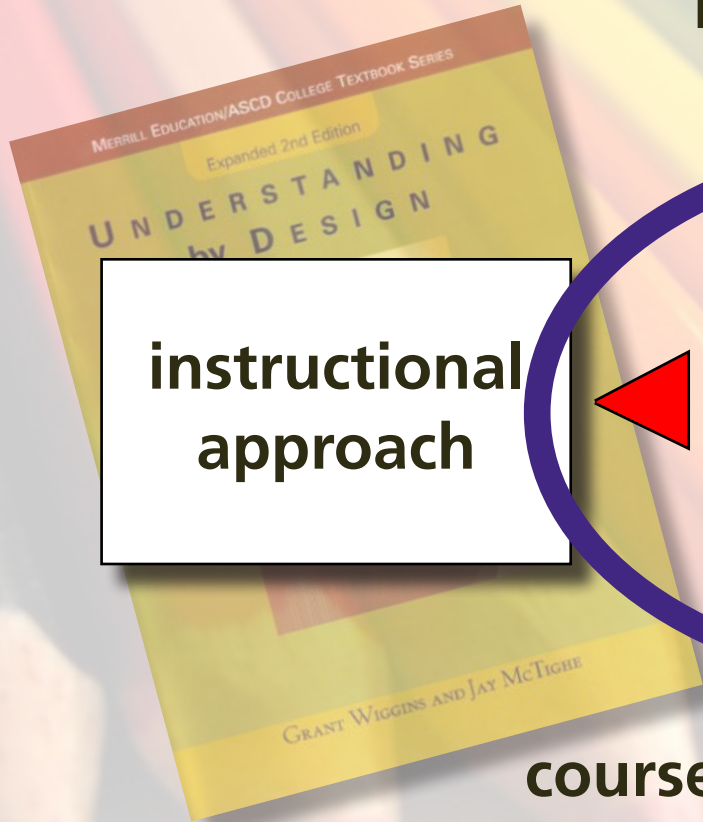
**course defined by outcomes**

**1 purposes**

**2 problems**

**3 improvements**

# Backward design



**instructional approach**

**acceptable evidence**

**desired outcomes**



**course defined by outcomes**

- 1** purposes
- 2** problems
- 3** improvements



**4**

**resolve coach/judge conflict**

**1** purposes

**2** problems

**3** improvements

use external evaluators

1 purposes

2 problems

3 improvements



# peer- and self-assessment

1 purposes

2 problems

3 improvements

# Calibrated Peer Review

[cpr.molsci.ucla.edu](http://cpr.molsci.ucla.edu)

- 1 purposes
- 2 problems
- 3 improvements

# Calibrated Peer Review

[cpr.molsci.ucla.edu](http://cpr.molsci.ucla.edu)

- 1 purposes
- 2 problems
- 3 improvements

# Step 1: assignment & rubric

[cpr.molsci.ucla.edu](http://cpr.molsci.ucla.edu)

1 purposes

2 problems

3 improvements

...st the three important concepts

3 = admin...  
exceeds expectations  
(rarely selected)

### WRITING RUBRIC

**1 = needs improvement**  
does not meet expectations entirely

**2 = satisfactory**  
meets expectations  
(what you should aim for)

Catchy title drawing audience into article

Compelling audience appropriate hook or lead present AND first few paragraphs orient lay reader to subject

All paragraphs are short (1-5 sentences)

Headings structure paper in organized, logical way AND paragraphs linked by transitions

Ends compellingly with an important idea or though provoking question AND ties back to title and opening hook

Rubric for Calibrated Peer Review

#### Structure

Title

Opening

Paragraph length

Organization

Closing

Wordy, long, unimaginative, or inappropriate title

Missing a "hook" or a lead in the first paragraphs AND does not orient reader to subject

Many paragraphs are long (6 or more sentences)

Lacks organization, no logical headings, no transitions between paragraphs

Does not end compellingly or with an important idea AND does not tie back to opening

Contains incorrect, misstated, irrelevant, or unnecessary facts

Does not back up facts with proper, convincing, or interesting sources or evidence

Mostly predictable based on available

Basic title

Hook or lead present OR first few paragraphs orient reader to subject

Some paragraphs are long (6 or more sentences), most are short (1-5 sentences)

A few headings OR most paragraphs linked by transitions

Summary-like closing, but does not tie back to title or opening hook

All facts are 100% correct, relevant, and necessary

Most, but not all, facts backed up with proper, convincing, or interesting sources or evidence

Some originality apparent

Material appropriate and aimed at target audience AND mostly avoids scientific contains no colloquialisms or uses clearly

Includes fact-checked expert and/or lay testimony (newspaper article only)

Original presentation of material; uses the unexpected to capture attention

Material appropriate and aimed at target audience AND relates to practical/everyday concerns AND uses analogies or other techniques to relate unfamiliar content to familiar concepts; no jargon, colloquialisms, or acronyms

cpr.molsci.ucla.edu

Content/Ideas

Scientific ideas

Sources/evidence

1 purposes

2 problems

3 improvements

Step 2: upload

Step 3: review

[cpr.molsci.ucla.edu](http://cpr.molsci.ucla.edu)

1 purposes

2 problems

3 improvements

**MEDIUM**

**HIGH**

UPLOAD

**LOW**

nt new addition to night sky  
quires fear and awe – Mona Lisa

By now everyone has noticed the  
mistakable new addition to our sky, which  
outshines the brightest star at night and  
continues to shine alongside the sun during  
the day. None of us have seen such a sight in  
the course of our lives and for many it has  
served as a jarring reminder of the violent  
and powerful cosmic events that occur in  
what often appears to be a calm and constant

# The New York Times

January 20, 2009

## OBSERVATORY Spectacular Supernova Observed

By John Glenn

New York, N.Y. – People around the world witnessed the  
in recorded history this morning. The supernova, named  
Eastern Time, appearing as bright as the full moon. At  
continued to shine for several hours.

Traffic was interrupted in New York City, as early-ris  
ers of the amazing sight. As of press time, the

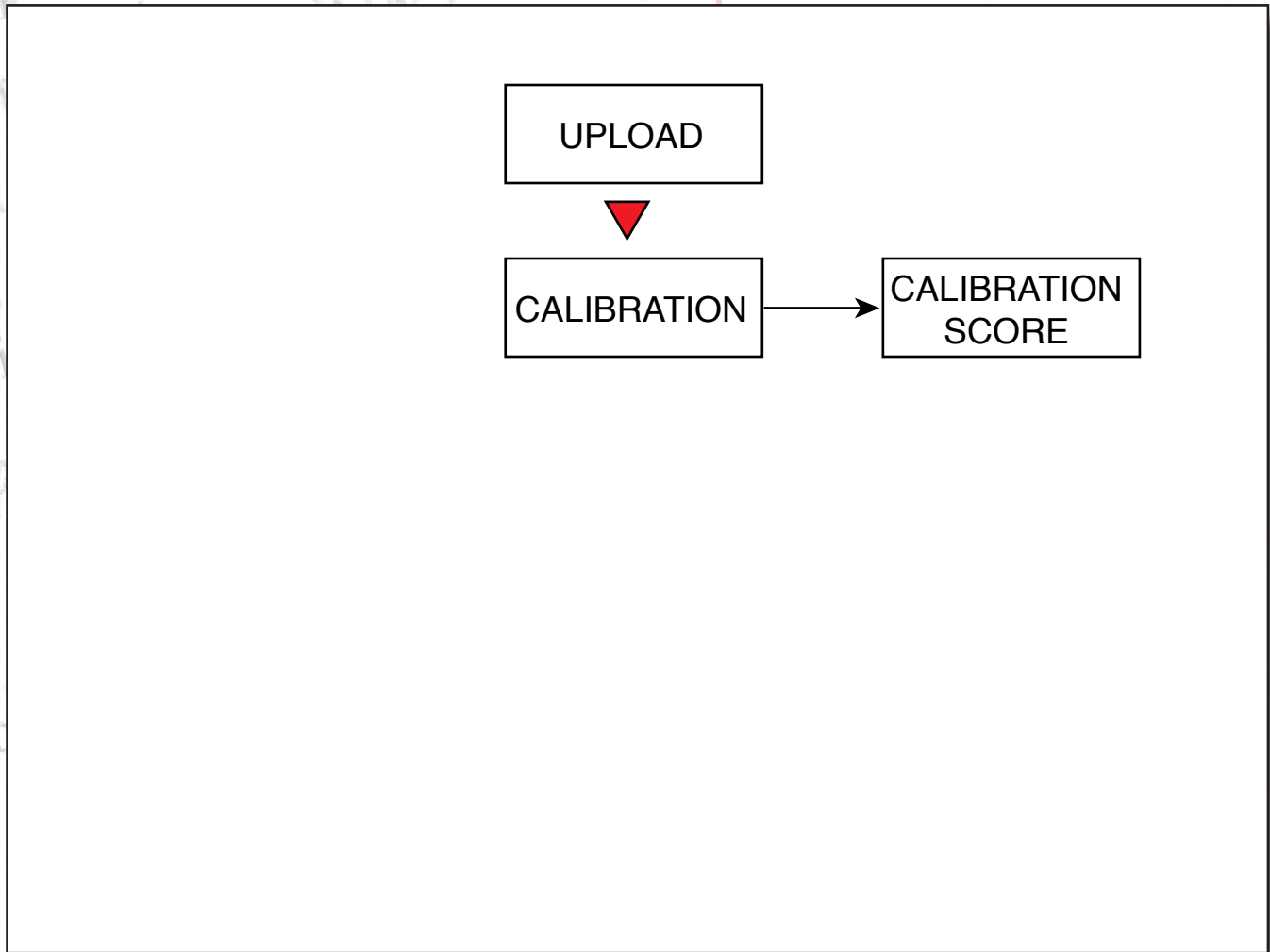
Galileo  
20 January 2008

Yesterday at about 4 p.m., I observed a peculiar  
appeared in the sky. A glowing flash emitted  
seconds, accompanied its appearance. The object  
it even in broad daylight. How did this unprecedented  
its consequences for Earth? In order to understand  
on Earth will most likely ever see again, we have  
galaxies. To fully appreciate it and not be alarmed  
understand the life cycle of stars and how they  
classified as consisting of eight planets (Pluto, etc.)

- 1 purposes
- 2 problems
- 3 improvements

st the three important concepts  
Equilibrium  
Thermodynamics  
Kinetics (both)  
Describe the Law of definite  
A chemical compound  
Same proportion  
Unrelated, I saw  
5 pts) A chemical reaction do

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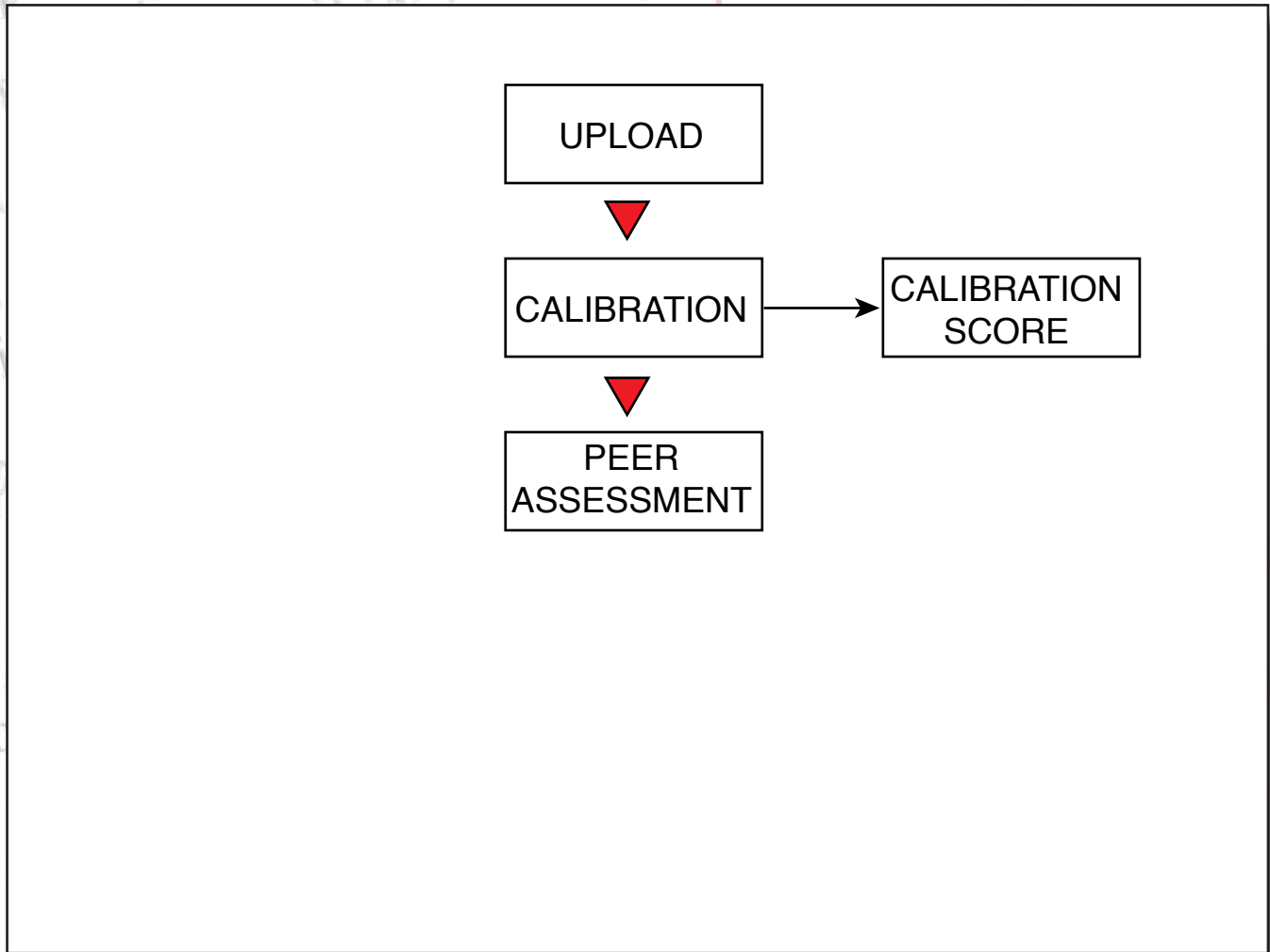


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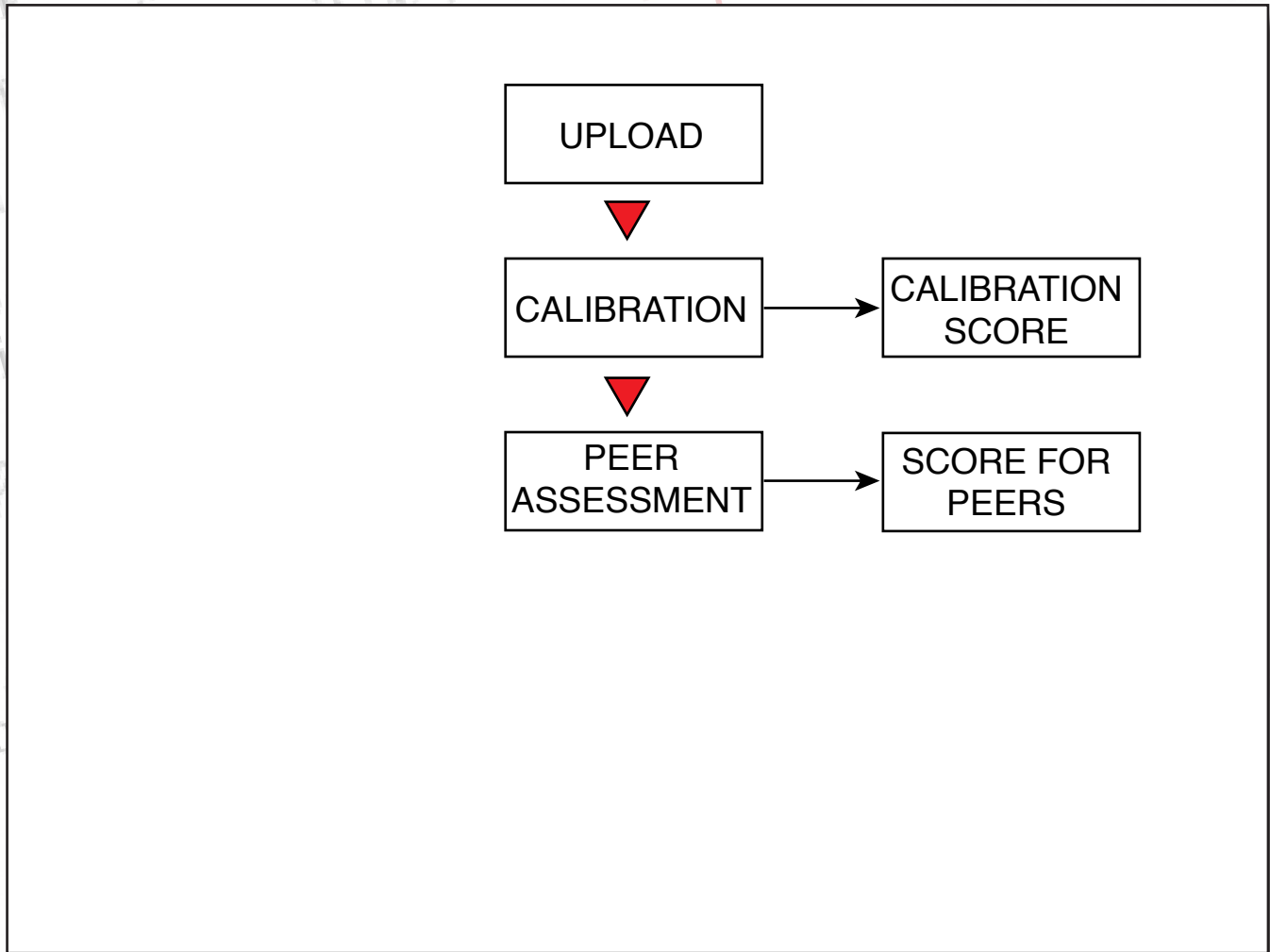
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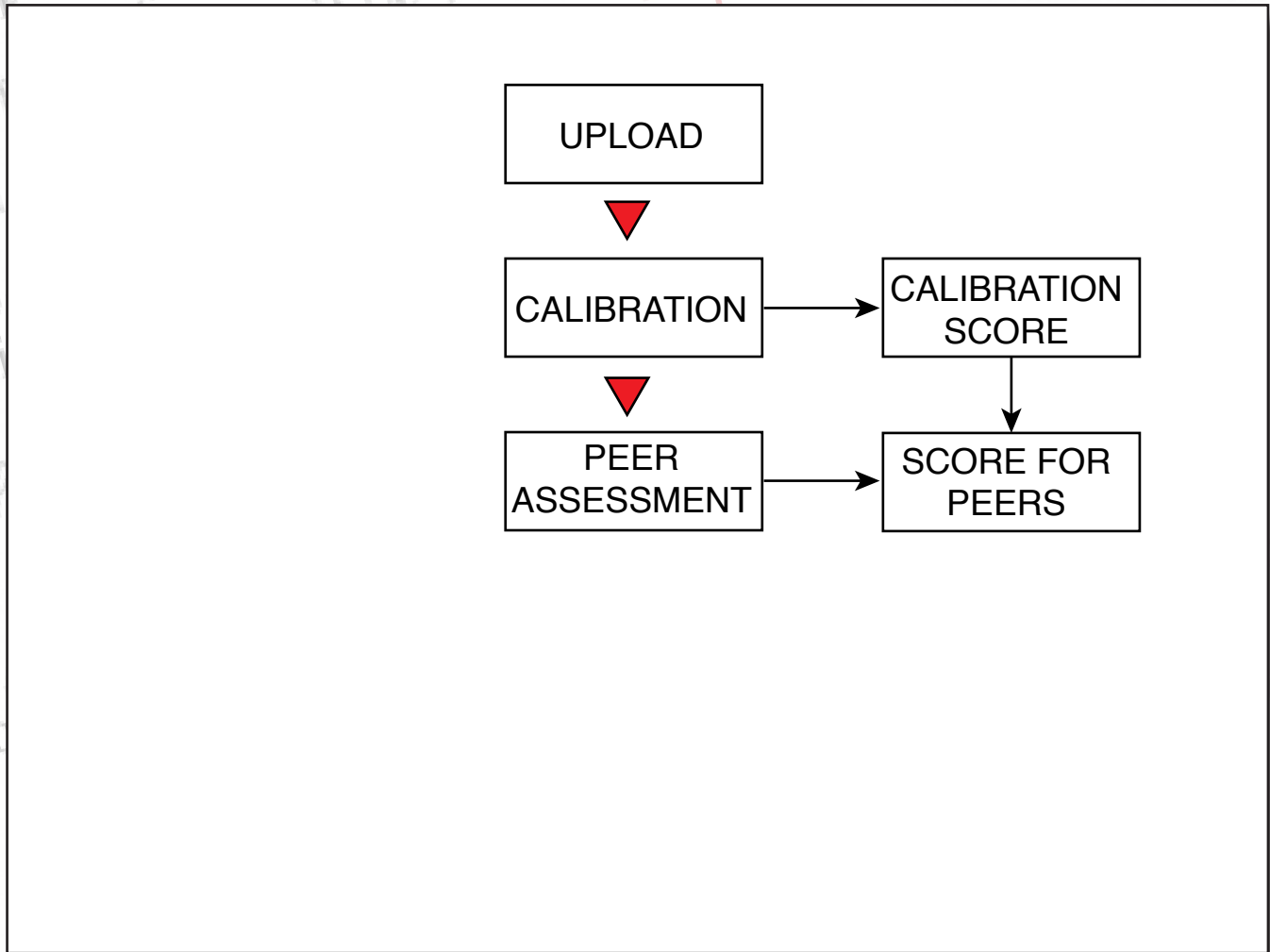


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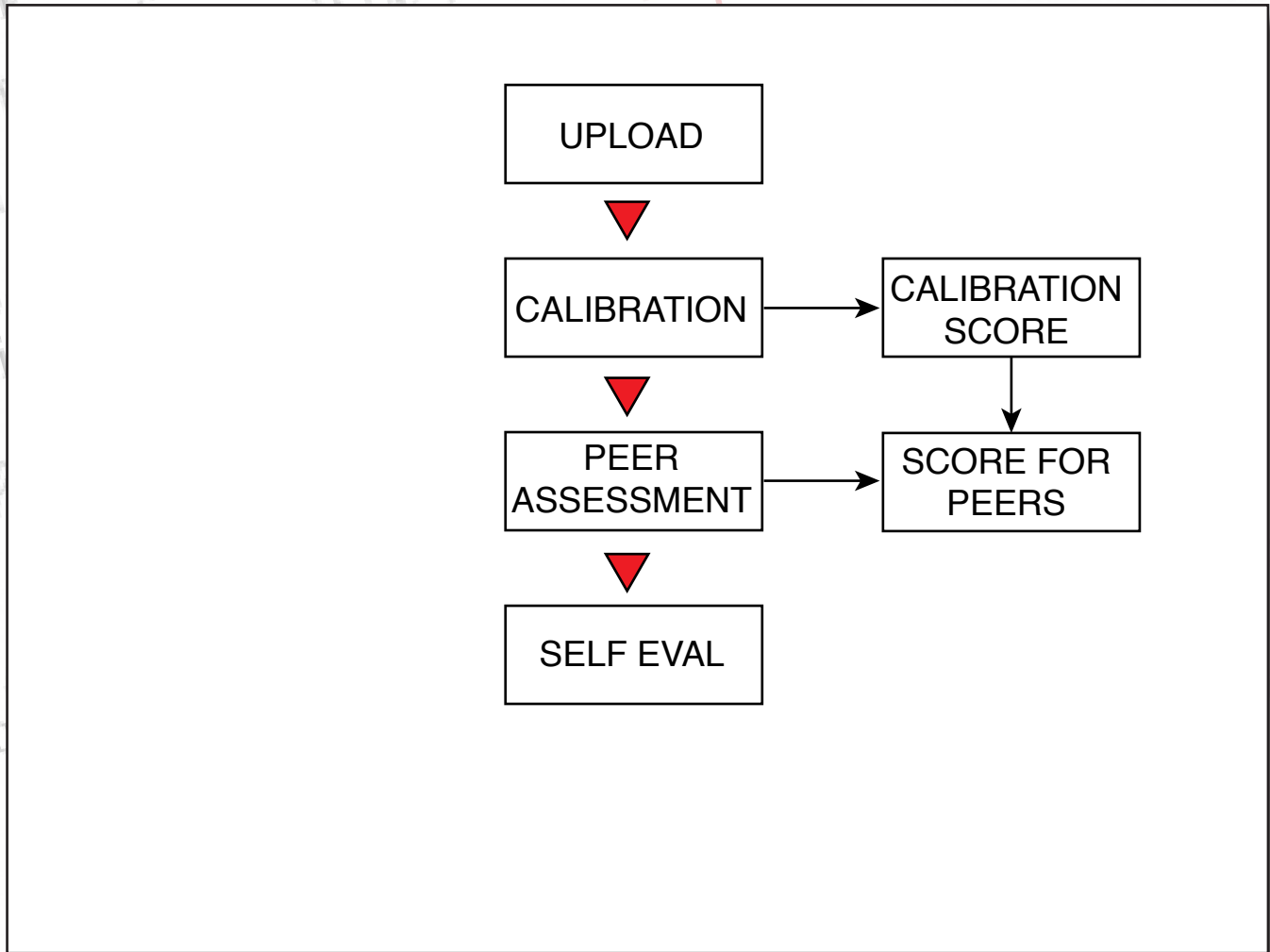


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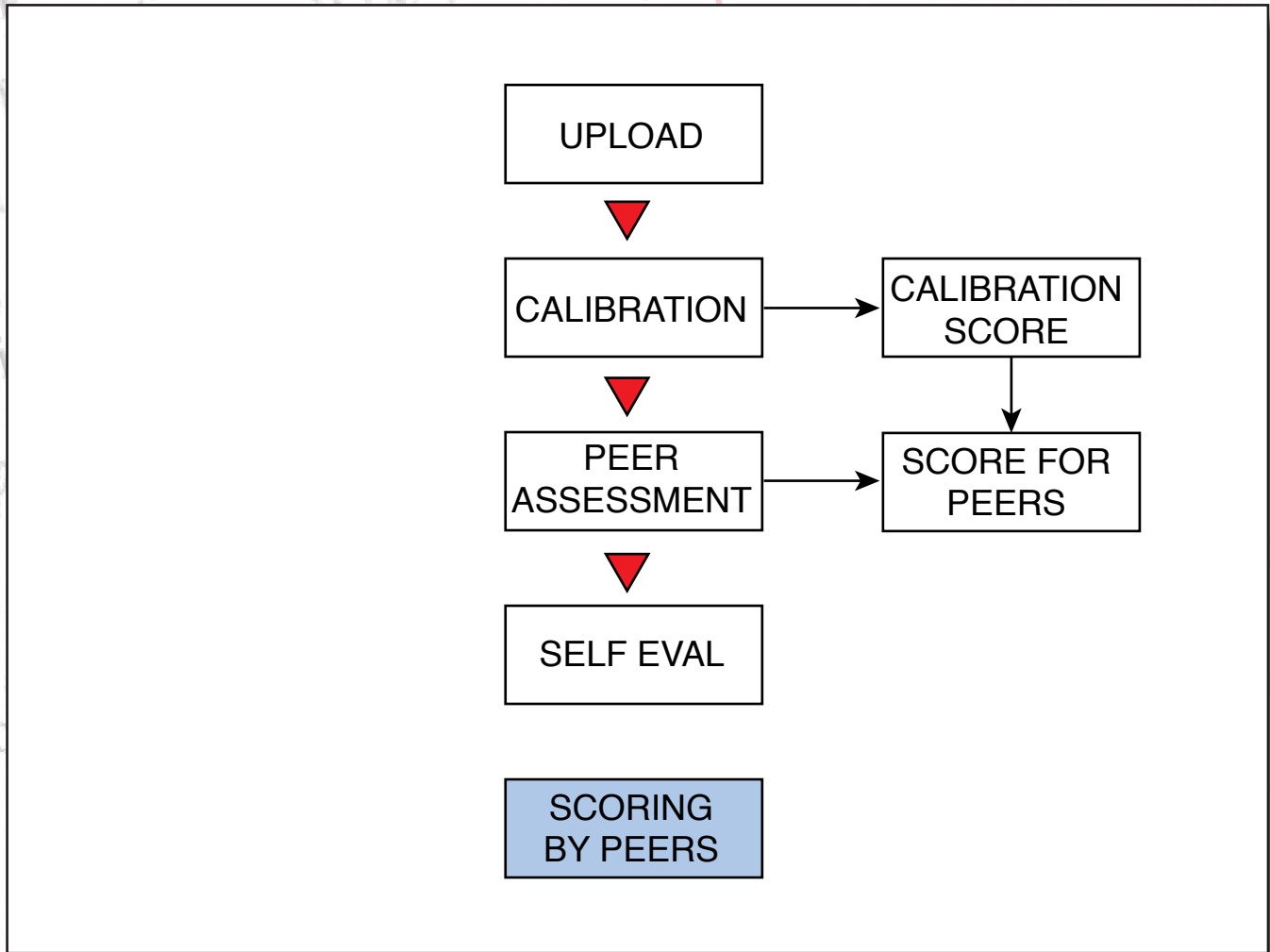
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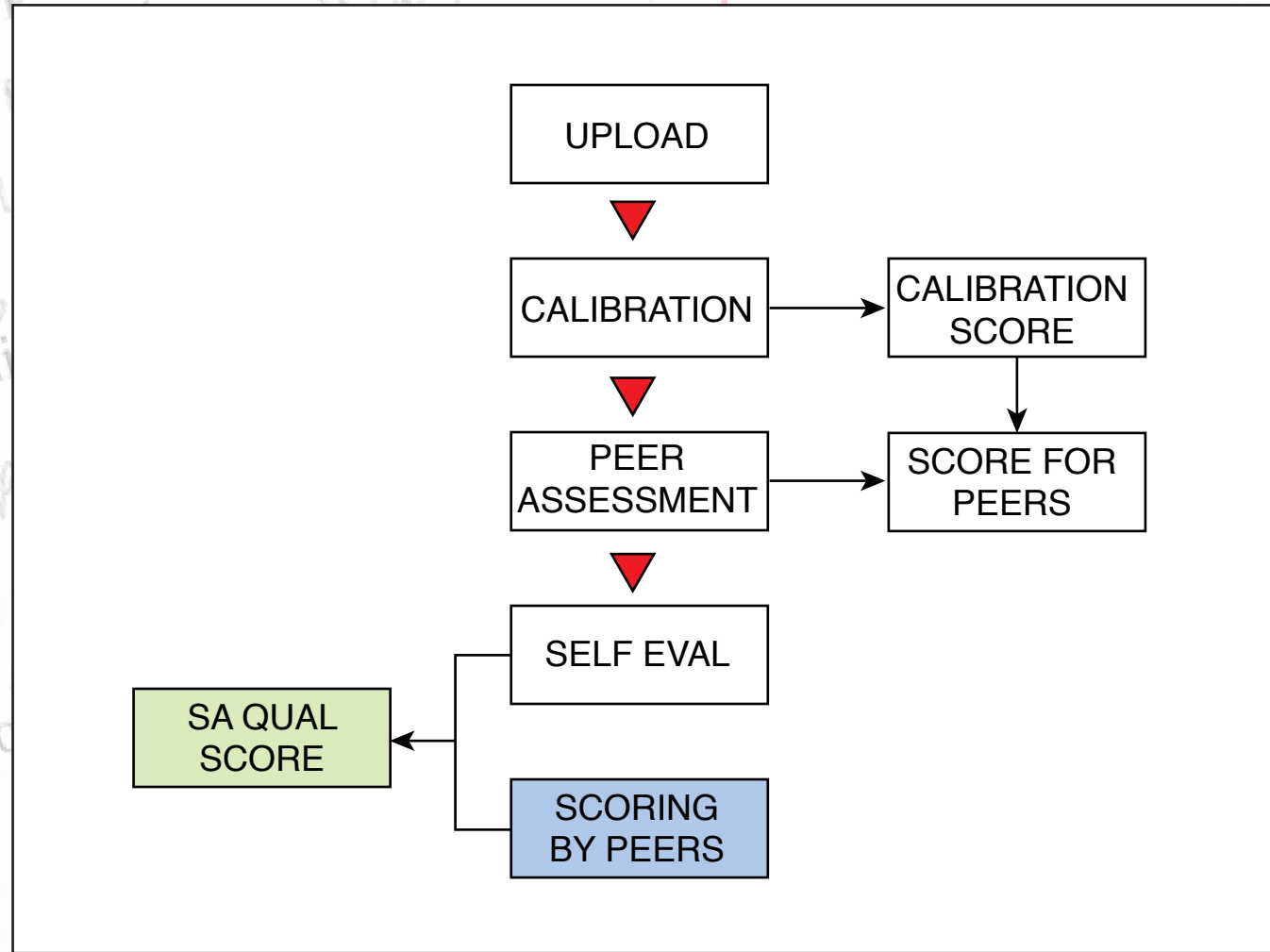


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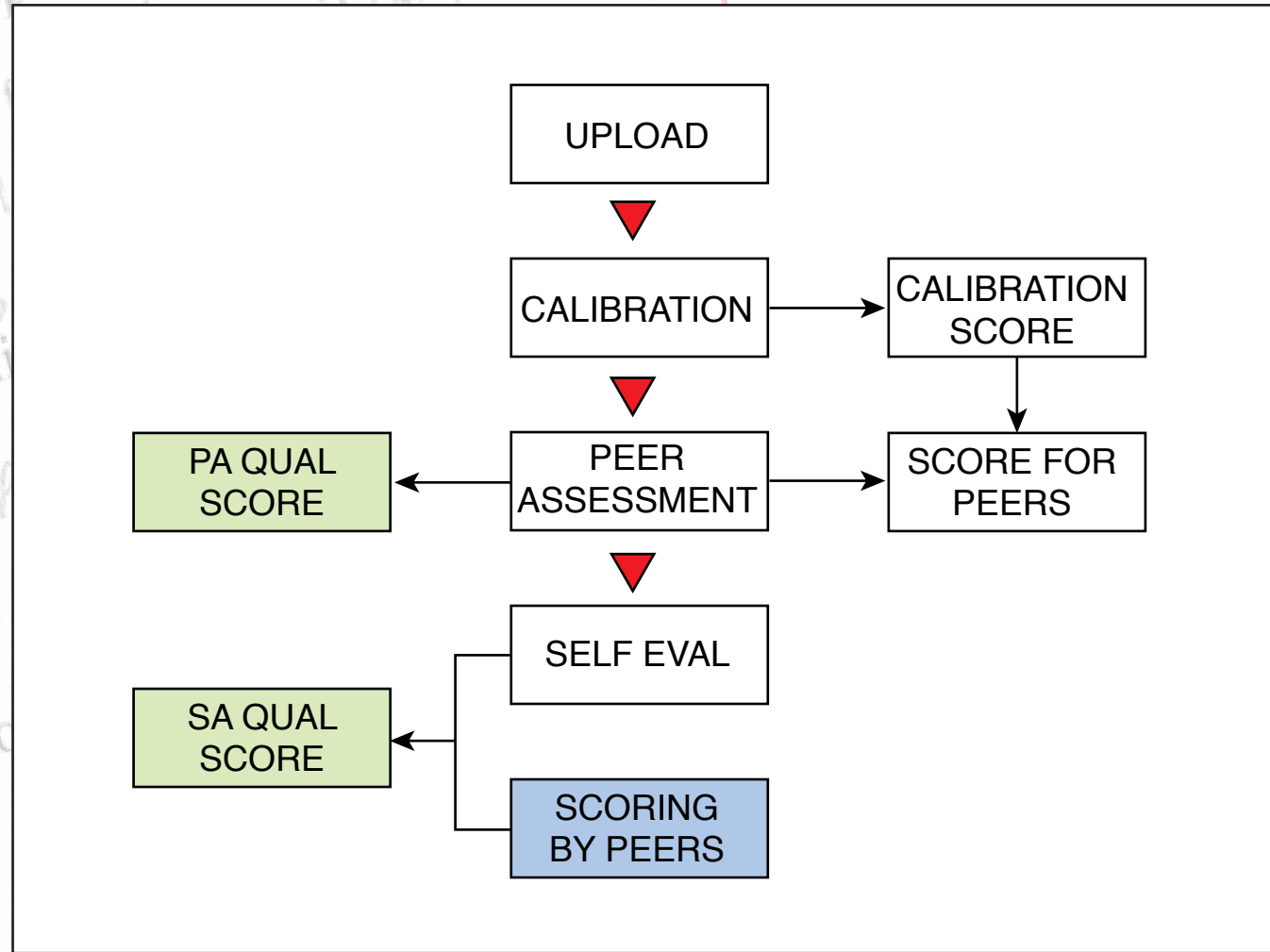
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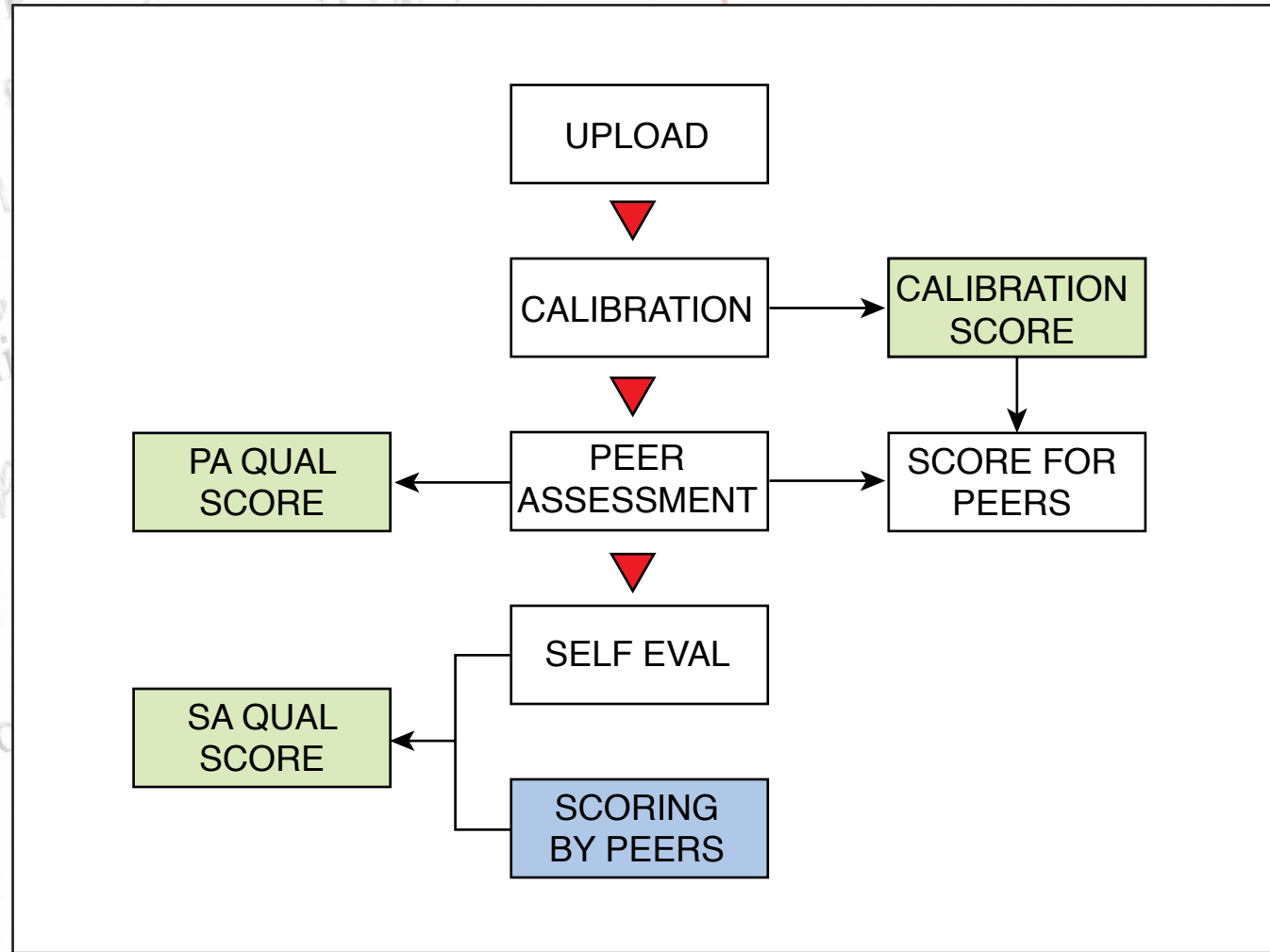
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A large, empty classroom with rows of desks and chairs. The text "rethink assessment" is overlaid in the center in a large, bold, black font with a blue outline. The classroom has a light blue floor with yellow and red lines, and a white wall with a door in the background.

**rethink  
assessment**



**mazur.harvard.edu**

**Follow me!**



**eric\_mazur**