AP50b Fall 2013

Problem Set 1

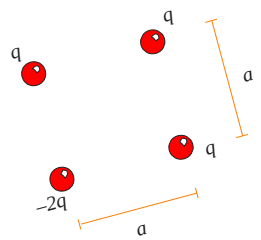
due W Feb 6 in class

Instructions: as we need to quickly scan your work so we can return it before the end of class, please:

- use 8.5 x 11" paper
- no-dog ears or torn out of ring-bound notebook
- dark ink (no light pencils)
- no staples
- name on each page
- single-sided (no writing on back)
- leave margins blank

1. ***Ink-Jet Printing.*** In an inkjet printer, letters are built up by squirting drops of ink at a piece of paper from a rapidly moving nozzle. The ink drops leave a nozzle and travel toward the paper, passing through a charging unit that gives each drop a positive charge by removing some electrons from it. The drops then pass between parallel deflecting plates where there is a uniform vertical electric field (to be discussed in Chapter 23). Estimate the number of atoms present in a droplet of ink.

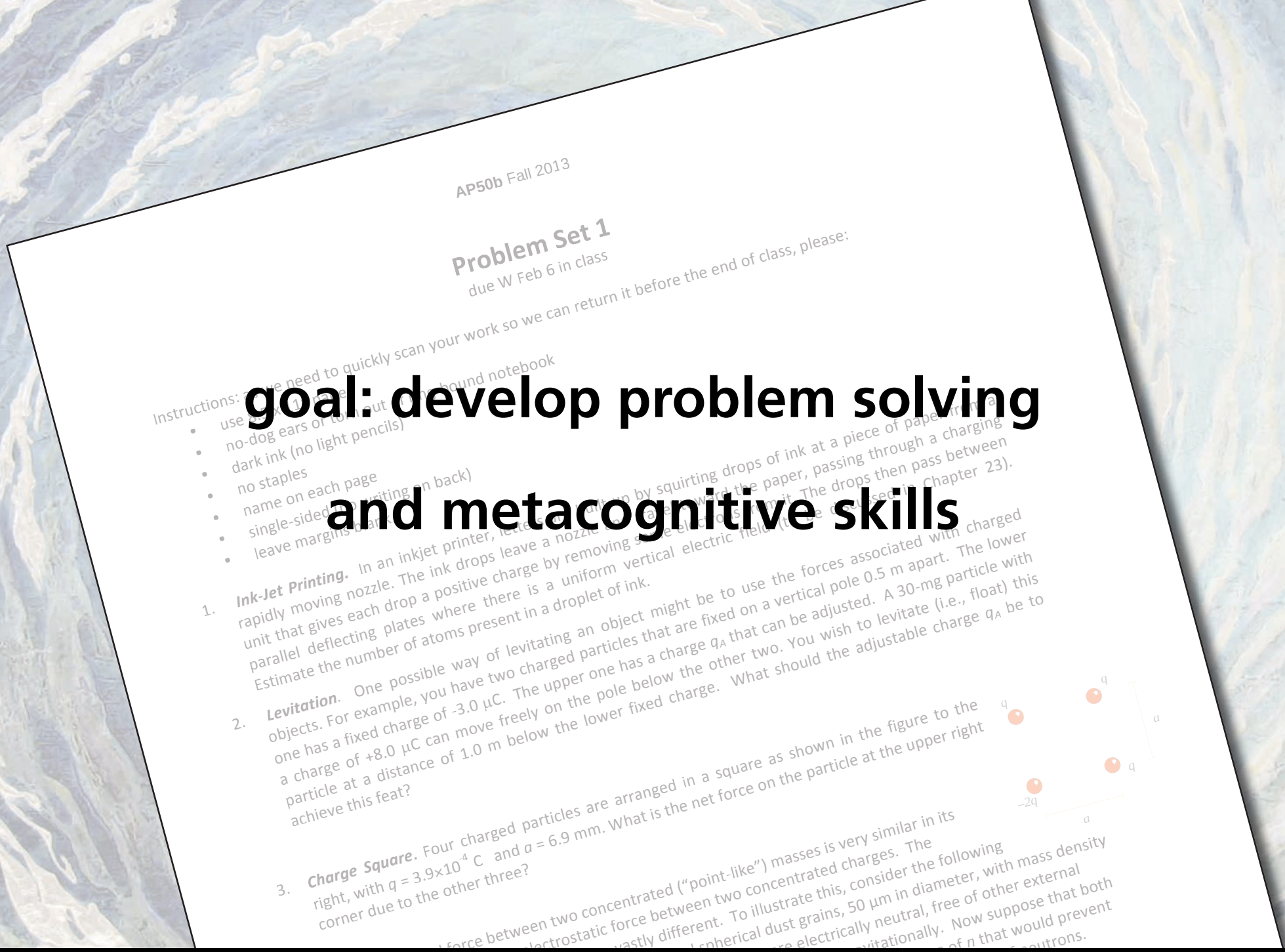
2. ***Levitation.*** One possible way of levitating an object might be to use the forces associated with charged objects. For example, you have two charged particles that are fixed on a vertical pole 0.5 m apart. The lower one has a fixed charge of -3.0 μC. The upper one has a charge q_A that can be adjusted. A 30-mg particle with a charge of +8.0 μC can move freely on the pole below the other two. You wish to levitate (i.e., float) this particle at a distance of 1.0 m below the lower fixed charge. What should the adjustable charge q_A be to achieve this feat?



3. ***Charge Square.*** Four charged particles are arranged in a square as shown in the figure to the right, with $q = 3.9\times10^{-4}$ C and $a = 6.9$ mm. What is the net force on the particle at the upper right corner due to the other three?

force between two concentrated ("point-like") masses is very similar in its
lectrostatic force between two concentrated charges. The
vastly different. To illustrate this, consider the following
spherical dust grains, 50 μm in diameter, with mass density
are electrically neutral, free of other external
vitationally. Now suppose that both
of n that would prevent
neutrons.

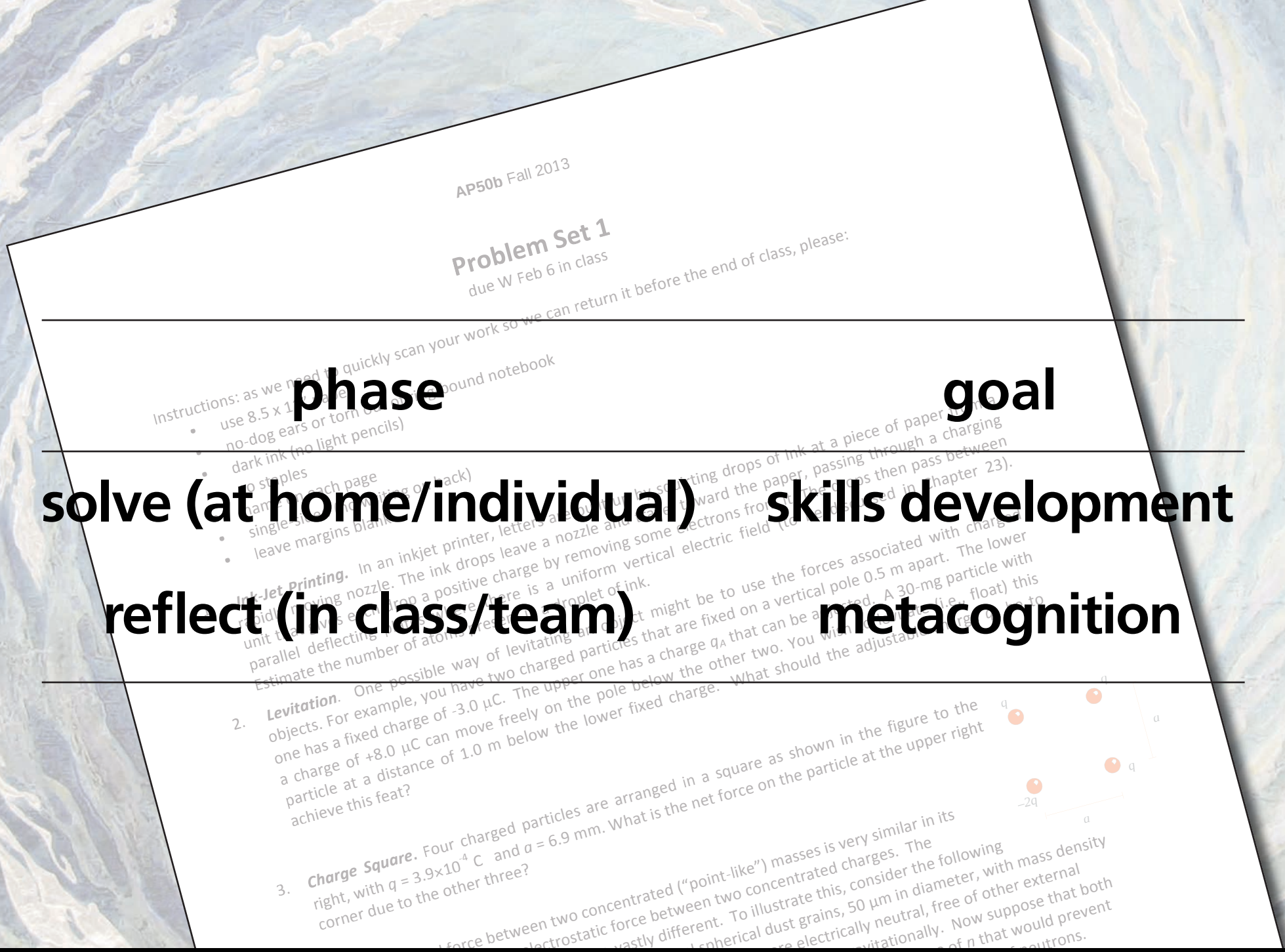
1 design **2** approach



goal: develop problem solving and metacognitive skills

1 design

2 approach



phase	goal
solve (at home/individual)	skills development
reflect (in class/team)	metacognition

1 design

2 approach

Problem Set Rubric

The goal of the problem sets is to develop problem-solving skills, not just to test your ability to obtain the right answer. You will receive the problem sets a week before they are due. Each problem sets involves both individual and team work.

Individual phase (at home): From the time you receive a problem set to the time it is due in class at 10 am, you are to work on the problem set **alone**. The work you complete during this phase will be evaluated on effort, not correctness. You may only use **blue or black ink** and you must attempt to solve each problem using the following 4-step procedure (see Section 1.8 in the textbook for additional details)

Getting Started — State the important information and summarize the problem. If possible, include a diagram. Note any assumptions you're making.

Devise Plan — Devise a plan of attack before diving into the solution. Break down the problem into smaller, manageable segments. Identify which physical relationships you can apply.

Execute Plan — Carry out your plan, explaining each step. The argument should be easy to follow. Articulate your thought process at each step (including roadblocks). Any variables should be clearly defined, and your diagrams should be labeled.

Evaluate Answer — Check each solution for reasonableness. There are many ways to justify your reasoning: check the symmetry of the solution, evaluate limiting or special cases, relate the solution to situations with known solutions, check units, use dimensional analysis, and/or check the order of magnitude of an answer.

You can consult the textbook and online resources, and you may consult the teaching staff by posting questions to the Problem Set Discussion on the course Web site. However, you may not consult other people, nor collaborate with your peers. It's ok to try hard and not succeed at first (only your effort is evaluated), but you must attempt every problem. If you reach the Evaluate stage and find that your answer does not seem reasonable, try to describe your thought process so you are prepared for a discussion with your team in class.

Team/Reflect phase (in class): On the due date of the problem set, you will work with your team in class to improve and/or correct your solutions, reflect on your work, and determine what you need to review. D
stage, you may only use **red ink** to write on your problem sets (pens will be provided in cl
minutes, your team will be provided with a solution set which you may use to
additional 45 minutes, your team must submit the marked-up proble
sheets for the entire team and a team scoring sheet.

It is the team's responsibility to en
solutions together with a
team score. Thi
only

1 design

2 approach

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1 design 2 approach

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Devise Plan	Devise a plan of attack before diving into the solution. Break down manageable pieces. Identify relevant physical laws. You can a
Execute Plan	Carry out your plan, explaining each step. The argument should be your thought process at each step (including roadblocks). Any va defined, and your diagrams should be labeled.
Evaluate Answer	Check each solution for reasonableness. There are many ways to just the symmetry of the solution, evaluate limiting or special cases situations with known solutions, check units, use dimensional analysi of magnitude of an answer.

at home:

implement 4-step procedure

(evaluated on effort)

You can consult the textbook and online resources, and you may consult the teaching sta

1 design

2 approach

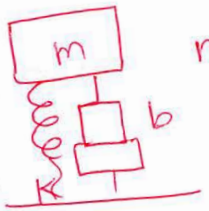
Applied Physics 50a

① Estimate damping coeff. for a shock absorber on a midsize car.

Getting started.

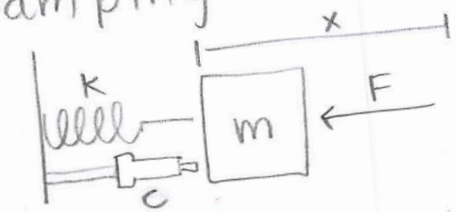
car moving forward

$F = m \cdot a$



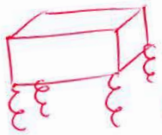
$$m\frac{d^2x}{dt^2} + b\frac{dx}{dt} + kx = 0$$

Damping coeff (c)



$F_s = -kx$

$F_d = -cv$



$k_1 + k_2 + k_3 + k_4 = 4k_1$

Create a plan.

set $F_s + F_d$ equal to force of car moving forward and solve for c.

- Approximate k of spring = 490.5 N/m
  x (distance compressed) = 0.1 m

$\sum F_x = F_{Ec}^{G} - F_{sc}^{c} = \Delta mg - k(x_{eq} - x_0)$

Translational eq $= \sum F_x = 0$

Execute plan.

$F = m \cdot a$

- Estimate mass of mid-size car = 1500 kg
- Est. accel. of midsize car: 5 m/s

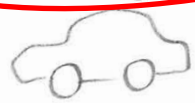
$k = \frac{\Delta mg}{\ldots}$

1 design 2 approach

Applied Physics 50a

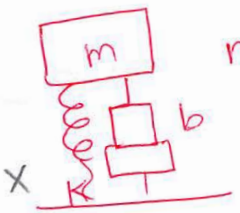
① Estimate damping coeff. for a shock absorber on a midsize car.

Getting started.



car moving forward

$F = m \cdot a$



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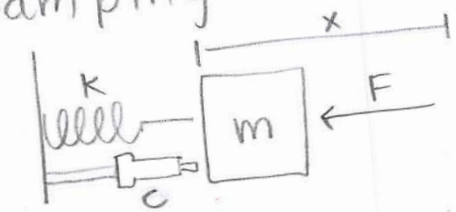

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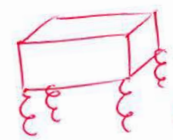

$k_1 + k_2 + k_3 + k_4 = 4k_1$

Create a plan.

Set $F_s + F_d$ equal to force of car moving forward and solve for c.

- Approximate k of spring = 490.5 N/m
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$\Sigma F_x = F_{Ec}^{G} - F_{sc}^{c} = \Delta mg - k(x_{eq} - x_0)$

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1 design 2 approach

Applied Physics 50a

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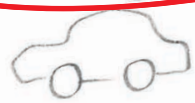
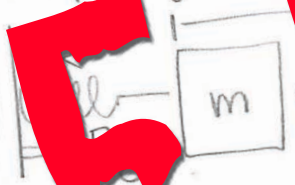


car moving forward

$F = m \cdot a$

Damping coeff (c)



$F_s = kx$

F_d

$\frac{dx}{\ldots} + k \ldots = 0$

$k_1 + k_2 + k_3 + k_4 = 4k_1$

Create a plan.

Set F_d equal to force of car moving forward and solve for c.

- Approximate k of spring = 490.5 N/m
  x (distance compressed) = 0.1 m

F_{sc}^{c}

F_{Ec}^{G}

$\sum F_x = F_{Ec}^{G} - F_{sc}^{c} = \Delta mg - k(x_{eq} - x_0)$

Translational eq $= \sum F_x = 0$

Execute plan.

$F = m \cdot a$

- Estimate mass of mid-size car = 1500 kg
- Est. accel. of midsize car: 5 m/s

$k = \frac{\Delta mg}{\ldots}$

25 pages!

1 design

2 approach

with your peers. It's ok to try hard and not succeed at first (only your effort is evaluate every problem. If you reach the Evaluate stage and find that your answer does not describe your thought process so you are prepared for a discussion with your team in clas

Team/Reflect phase (in class): On the due date of the problem set, you will work w improve and/or correct your solutions, reflect on your work, and determine what you ne stage, you may only use **red ink** to write on your problem sets (pens will be provided i minutes, your team will be provided with a solution set which you may use to confirm additional 45 minutes, your team must submit the marked-up problem sets together w sheets for the entire team and a team scoring sheet.

It is the team's responsibility to ensure that *all* team members hand-in complete an solutions together with a completed reflection sheet, because your team's submitted w team score. This means that if you do not put in adequate effort before the Team/Reflect only your own score, but also that of your team members. Likewise, it is important to your team marks his/her work up correctly during the Team/Reflect phase.

Important: Writing on the problem set in class in any other color but red will be considere

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in class:

mark up/improve solutions

complete reflection sheet

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② continued.

c) Maximum transverse speed.

Use $\lambda = \frac{v}{f}$; solve for v.

d) Length would have to be λ or 1½ wavelength, etc.

Execute plan.

a) $y = 0.2 \sin[\pi(0.5x - 100t)] = 0.5\pi(x - 200t)$

~~$x(t) = A \sin(\omega t + \phi_i$~~ $y = A \sin[k(x - ct)]$

k = wave #
c = wave speed
A = amplitude

- $\boxed{\text{amplitude} = 0.2 \text{ cm}}$

- $\boxed{\omega = \text{rotational speed} = \cancel{0.5\pi}}$ 200 cm/s

$\cancel{0.5\pi = \frac{2\pi}{T}} \Rightarrow$ $\boxed{T = \cancel{4} \text{ sec} = \text{period}}$ $\boxed{\frac{1}{50}}$ $\boxed{0.02 \text{ sec}}$

$k = \frac{2\pi}{\lambda} \rightarrow \lambda = \frac{2\pi}{k}$

$\boxed{50 \text{ sec}^{-1} = \text{Hz}}$

- $f = \frac{1}{T} = \boxed{\cancel{\frac{1}{4}} \text{ cycles/second} = \text{frequency}}$

$T = \frac{1}{f}$

$\lambda = \frac{v}{f}$

$\hookrightarrow f = \frac{v}{\lambda} = \frac{200}{4} = 50$

- $\lambda = \frac{v}{f} = \frac{\cancel{0.5\pi}\ 200}{\cancel{1/4}\ 4} = \boxed{\cancel{4} \text{ cm}}$

- wave number $= \frac{2\pi}{\lambda} = \boxed{\frac{1}{2}\pi} = \boxed{0.5\pi}$
k

(shifted right)

$y = 0.2 \sin[\pi(0.5x - 100(\frac{1}{200}))]$

$[\pi(0.5x - 100(0)]$

1 design 2 approach

Problem Set Reflection

Describe what you **learned** from working on this problem set before coming to class and reviewing it in class. (Do you think you would be able to take the concepts you explored in this problem set and transfer those concepts in a whole new context?) For example, would you be able to solve a problem involving the same physics concepts, but of a form you have never seen before?). You may complete this part before coming to class in blue or black ink.

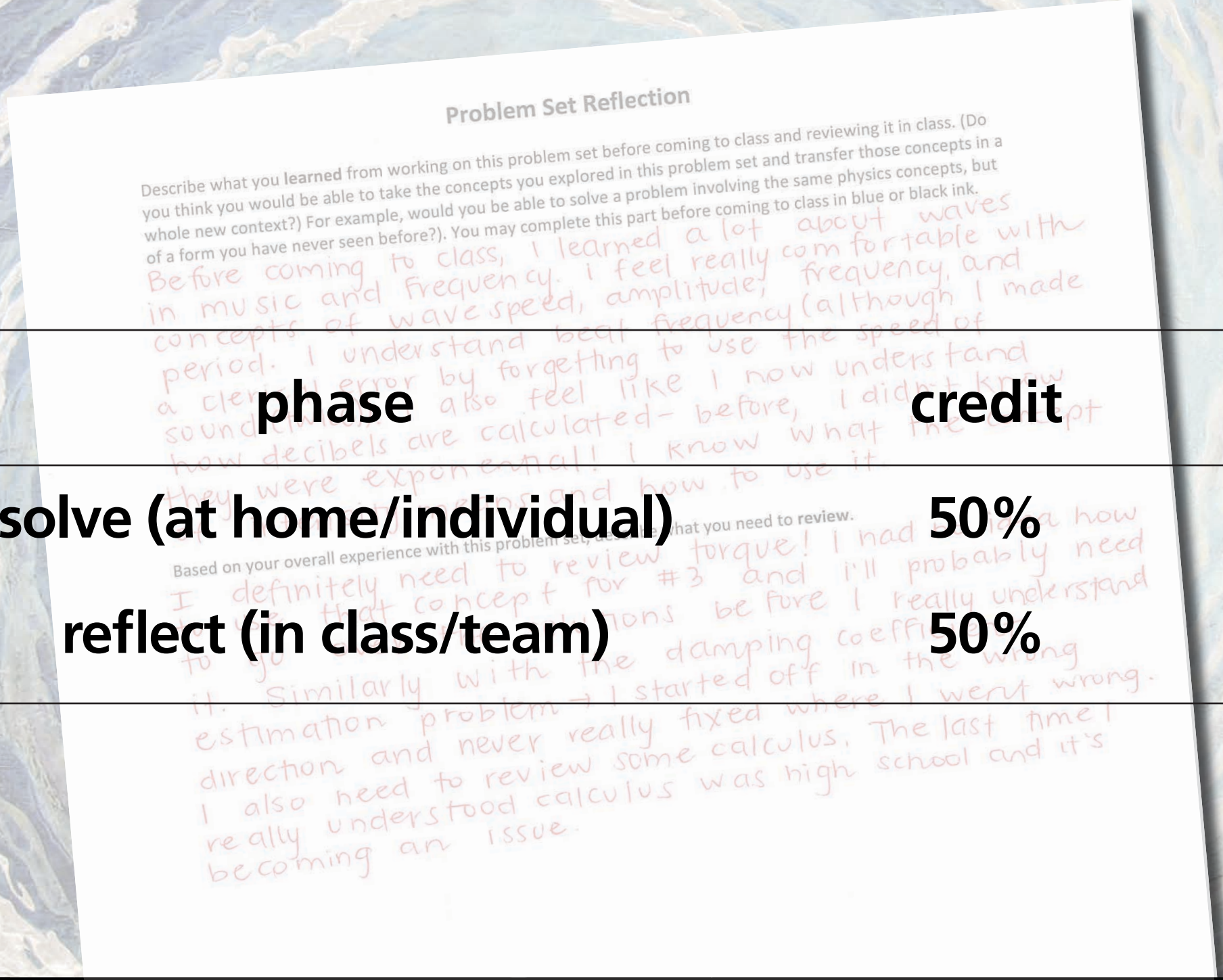
Before coming to class, I learned a lot about waves in music and frequency. I feel really comfortable with concepts of wave speed, amplitude, frequency, and period. I understand beat frequency (although I made a clerical error by forgetting to use the speed of sound (twice)). I also feel like I now understand how decibels are calculated - before, I didn't know they were exponential! I know what the concept of intensity means and how to use it.

Based on your overall experience with this problem set, describe what you need to **review**.

I definitely need to review torque! I had no idea how to use that concept for #3 and i'll probably need to go over the solutions before I really understand it. Similarly with the damping coefficient estimation problem → I started off in the wrong direction and never really fixed where I went wrong. I also need to review some calculus. The last time I really understood calculus was high school and it's becoming an issue.

1 design

2 approach

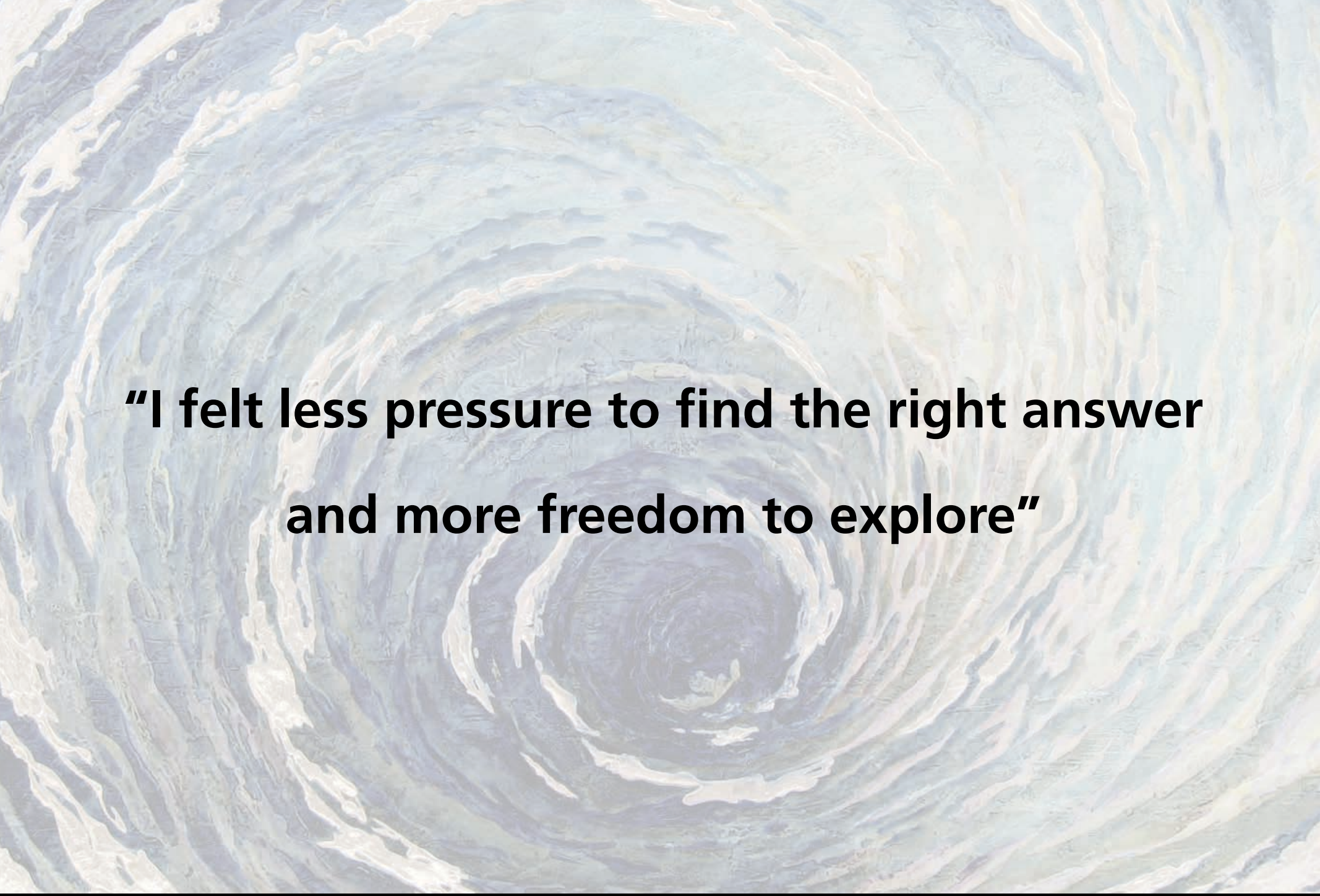


phase	credit
solve (at home/individual)	50%
reflect (in class/team)	50%

1 design

2 approach

“I was inspired and encouraged to do these problems on my own with the promise of collaborative work [the next day]”



“I felt less pressure to find the right answer and more freedom to explore”

In-class activities

understand

LC: Learning Catalytics — 90 min

Instructor poses question
Answer alone
Discuss in team
Answer again

bring device

Tutorial — 60 min

Work on worksheet with team
Explore concepts
Discuss with staff

apply

EA: Estimation Activity — 30 min

Estimate quantities
Develop individual strategy
Discuss and solve as team

EDA: Experimental Design Activity — 90 min

Conduct experiment with team
Take measurements
Analyze data
Carry out simulations

bring device

evaluate

Problem Set & Reflection — 90 min

Work problems alone BEFORE class
Discuss with team, mark up
Self-assess & turn in

RAA: Readiness Assurance Activity — 90 min

Part 1: solve problems alone
Open book, open internet
Part 2: solve with team

bring device

1 design 2 approach

1 design

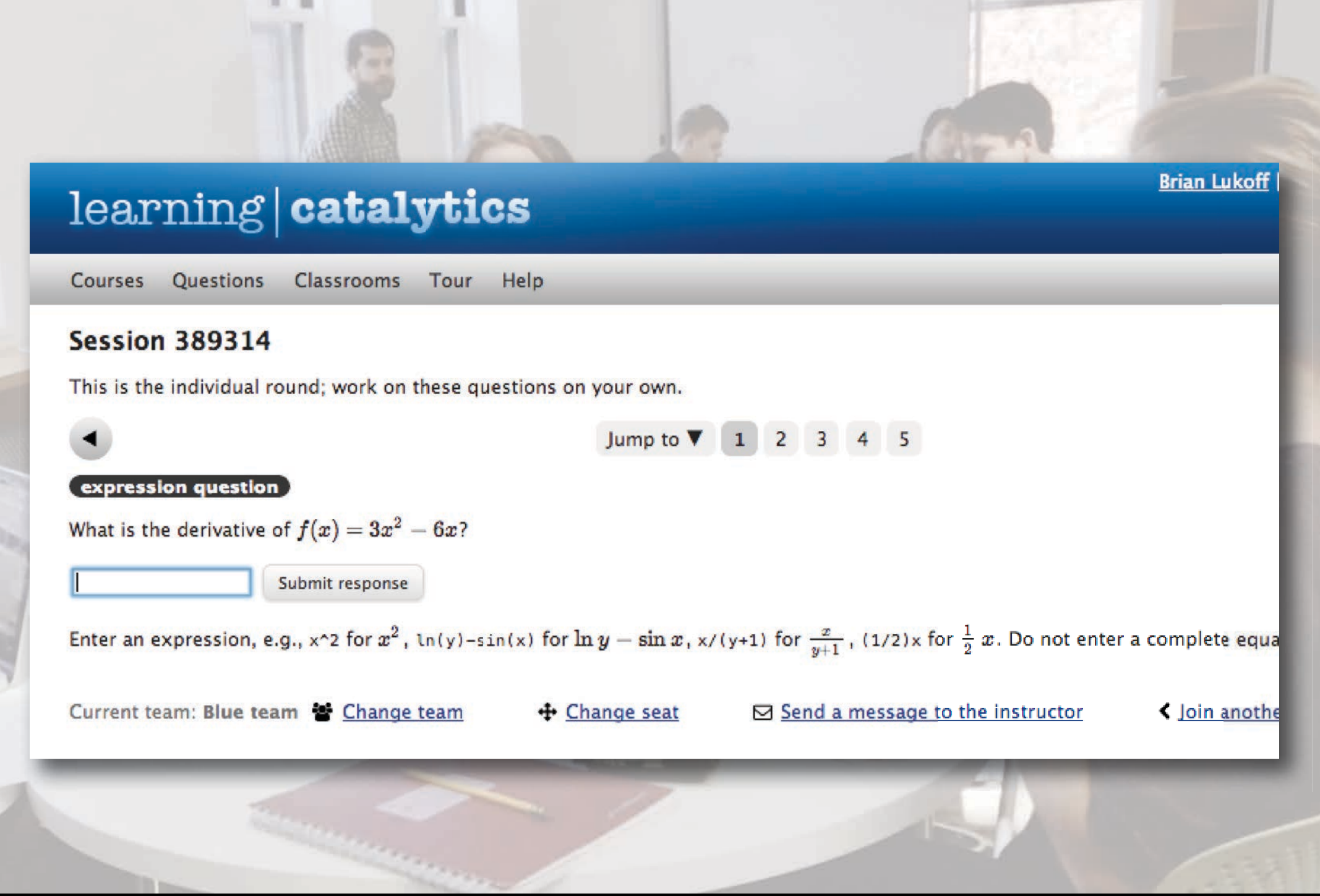
2 approach

goal: formative assessment

collaborative learning

1 design

2 approach



1 design

2 approach

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 design

2 approach

This is the individual round;

expression question

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

6x - 6

Submit response

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

1 design

2 approach

6x - 6 Brian Lukoff	**6x** Brent Jones	**6x - 6** Beth Sawyer	**6x^2 - 6** Kip Harmon

expression question

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

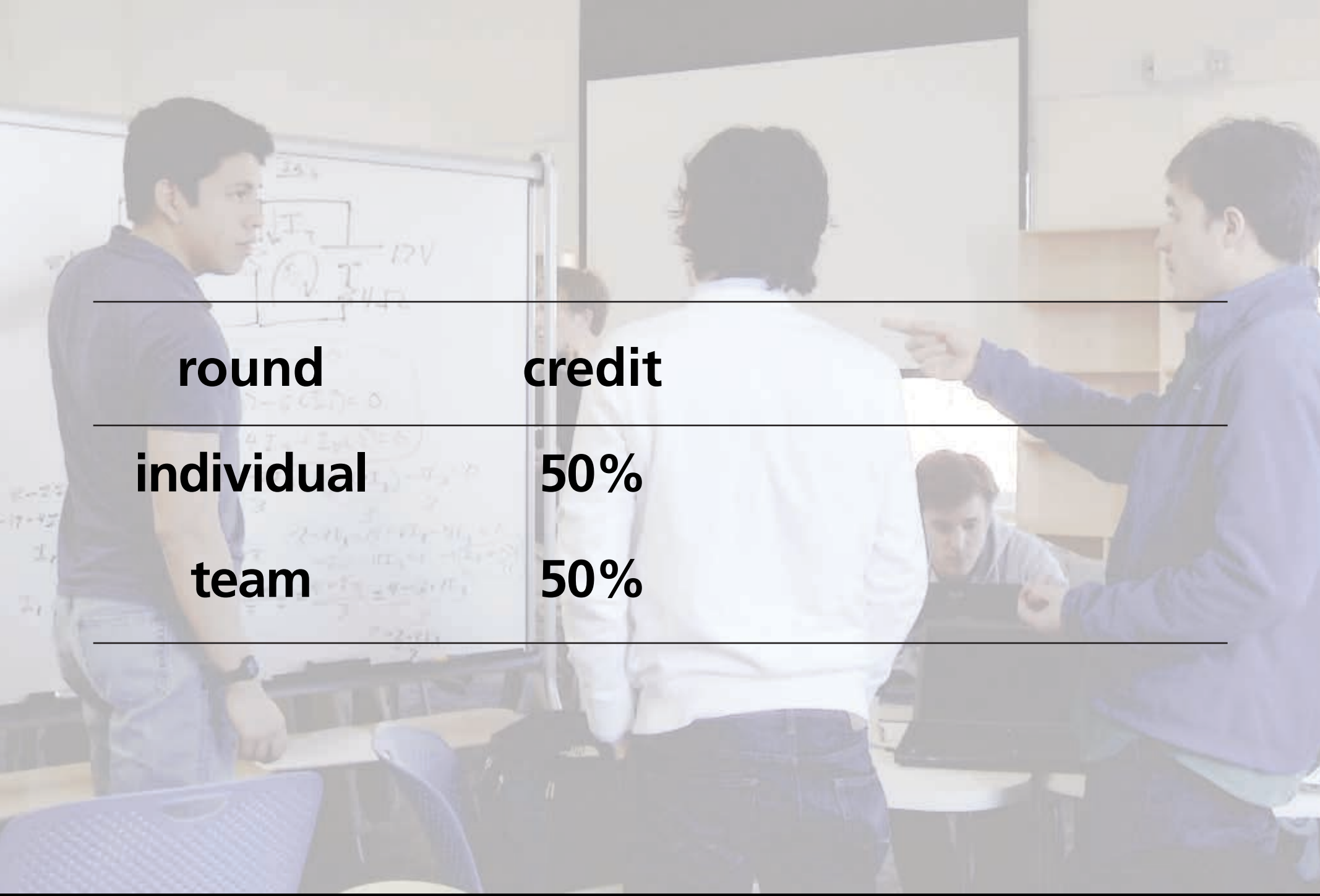
Submit response

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

1 design 2 approach

1 design

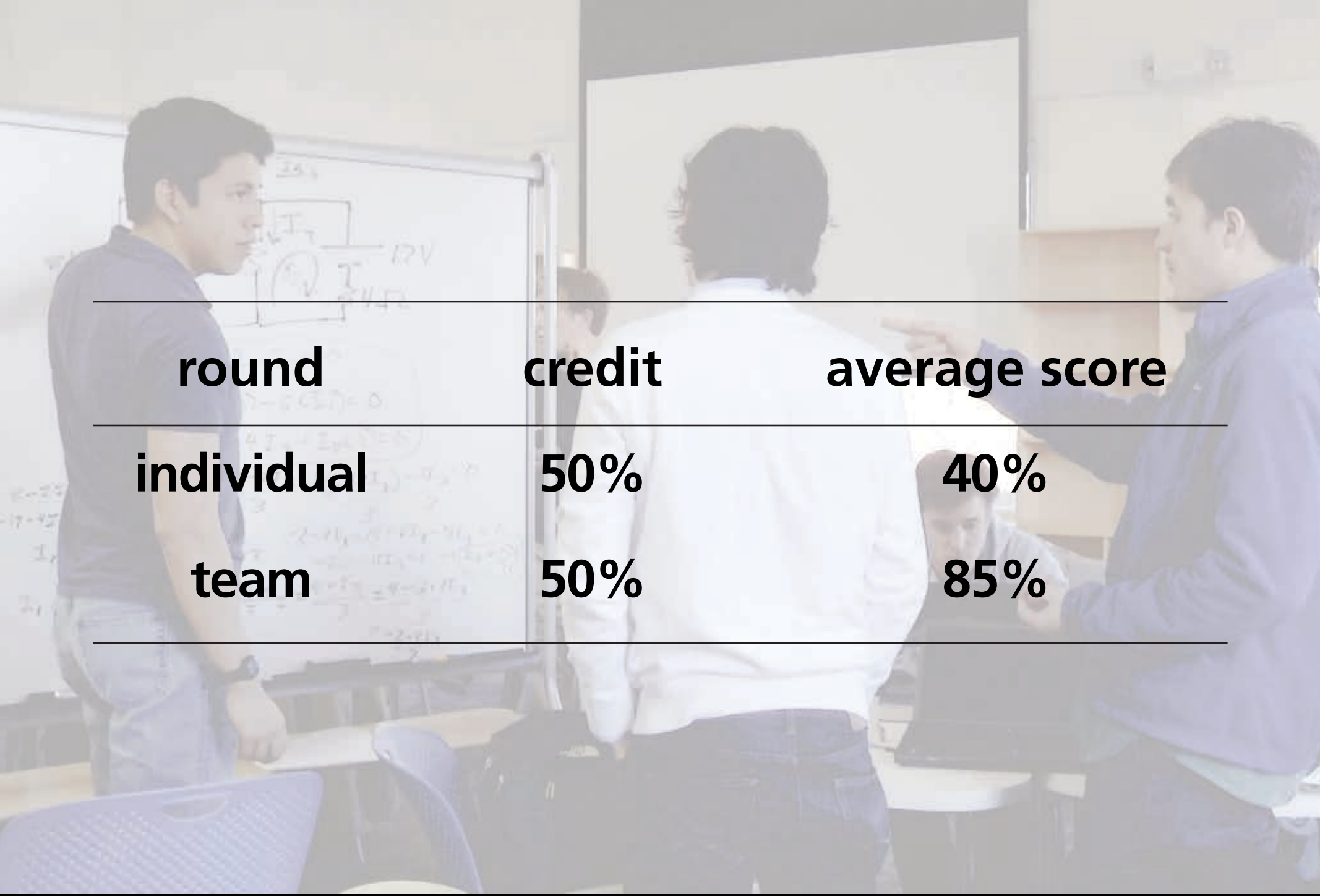
2 approach



round	credit
individual	50%
team	50%

1 design

2 approach



round	credit	average score
individual	50%	40%
team	50%	85%

Self, Peer, and Team assessment

1 design

2 approach

Team, Peer, and Self assessment

Self Assessment

	Self Assessment (you!)	Never	Rarely	Sometimes	About half the time	Most of the time	All of the time
1.	I **participate fully** in team activities						
2.	I come to class **well-prepared** for all team activities						
3.	I **communicate effectively and respectfully** with team members: • I express my opinions respectfully and with clarity • I listen respectfully to the perspectives and contributions of others • I collaborate effectively with team members to make decisions and resolve conflicts						
4.	**Attendance**: • I am present for team activities • I am on time/punctual						
5.	I **take responsibility** for my own part of team work and decision-making						
6.	I am **open to change** and willing to re-evaluate my own position in light of new information from others						

7.	Please describe one thing that you think you do well, that helps to make your team more effective

Team, Peer, and Self assessment

4. Relative contributions

How much did each team member contribute to the overall goals? Please note that the **sum of all relative contributions must be zero** — if one person did more than his/her fair share, then others must have done less.

	RELATIVE CONTRIBUTION						
	Less than fair share				More than fair share		
	Almost nothing	Much less	Somewhat less	Fair share	Somewhat more	Much more	Almost everything
Self							
Member 1							
Member 2							
Member 3							
Member 4							

Team, Peer, and Self assessment

Assessment Report

Assessment of You

You	Average Peer Assessment	Self Assessment
1. Participate fully in team activities	4.67	4
2. Come to class well-prepared for all team activities	4.67	4
3. Communicate effectively and respectfully with team members: • Express your opinions respectfully and with clarity • Listen respectfully to the perspectives and contributions of others • Collaborate effectively with team members to make decisions and resolve conflicts	4.83	4
4. Attendance: • You are present for team activities • On time/punctual	4.83	5
5. Take responsibility for your own part of team work and decision-making	4.83	4
6. Are open to change and willing to re-evaluate your own position in light of new information from others	4.67	4

Scale: 0 = Never, 1 = Rarely, 2 = Sometimes, 3 = About half the time, 4 = Most of the time, 5 = All of the

helping make your team more effective in the following ways (the quotes

1 design

2 approach

Team, Peer, and Self assessment

- You were great to work with and a true team player!
- Your ideas were a great contribution to our team
- You come up with good ideas
- You were really easy to work with and had a contagious enthusiasm

Assessment Report

Assessment of You

	You	Average Peer	Self Assessment
1. Participate fully in team activities		4.67	4
2. Come to class with preparation for team activities		4.67	
3. Communicate effectively and respectfully with team members • Express your opinions respectfully and with clarity • Listen respectfully to the perspectives and contributions of others • Collaborate effectively with team members to make decisions		4.83	4
4. Attendance: • You are present for team activities • On time/punctual		4.83	5
5. Take responsibility for your own part of team work and decision-making		4.83	4
6. Are open to change and willing to re-evaluate your own position in light of new information from others		4.67	4

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- You come up with good ideas
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"I felt as if I was able to effectively communicate my ideas, even though they may have been wrong… (still good for discussion, right?)"

Team, Peer, and Self assessment

- I would suggest being more responsive throughout the project process.
- Sometimes you're not engaged in activities
- It was hard to understand what you actually thought about an idea or project
- You could be more reasonable about what is actually feasible and what isn't

Assessment

self-directed learning

learning goals

team work

professionalism

Assessment

Scale: 3–0

self-directed learning

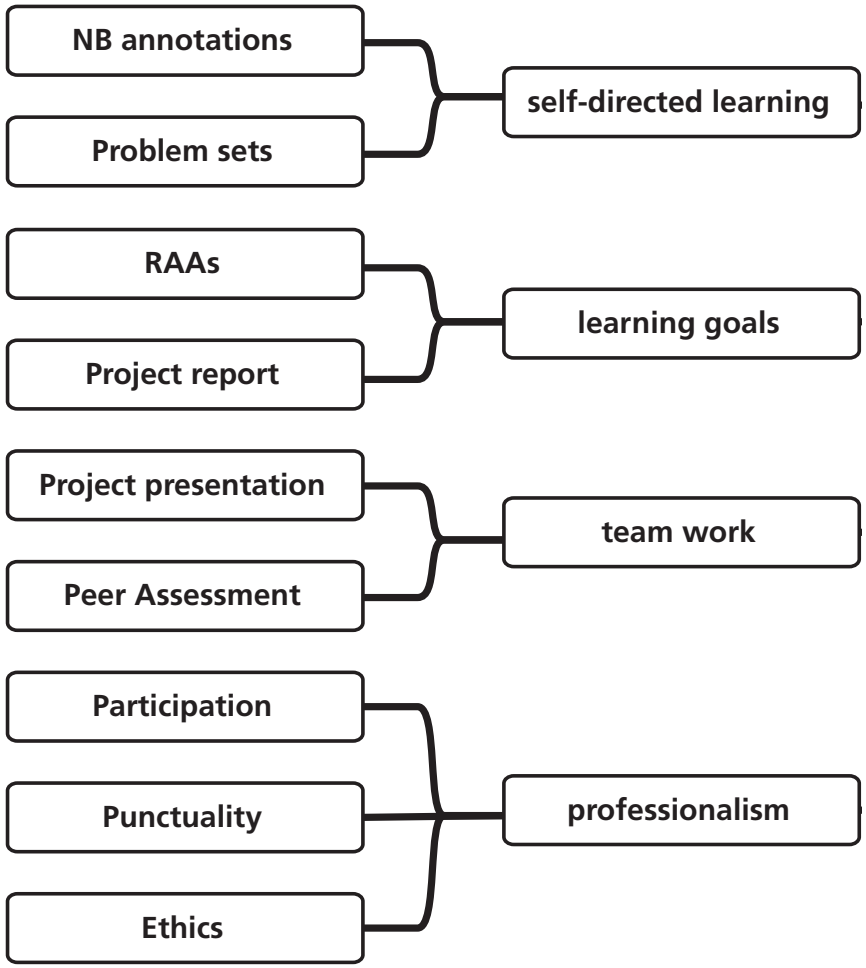
learning goals

team work

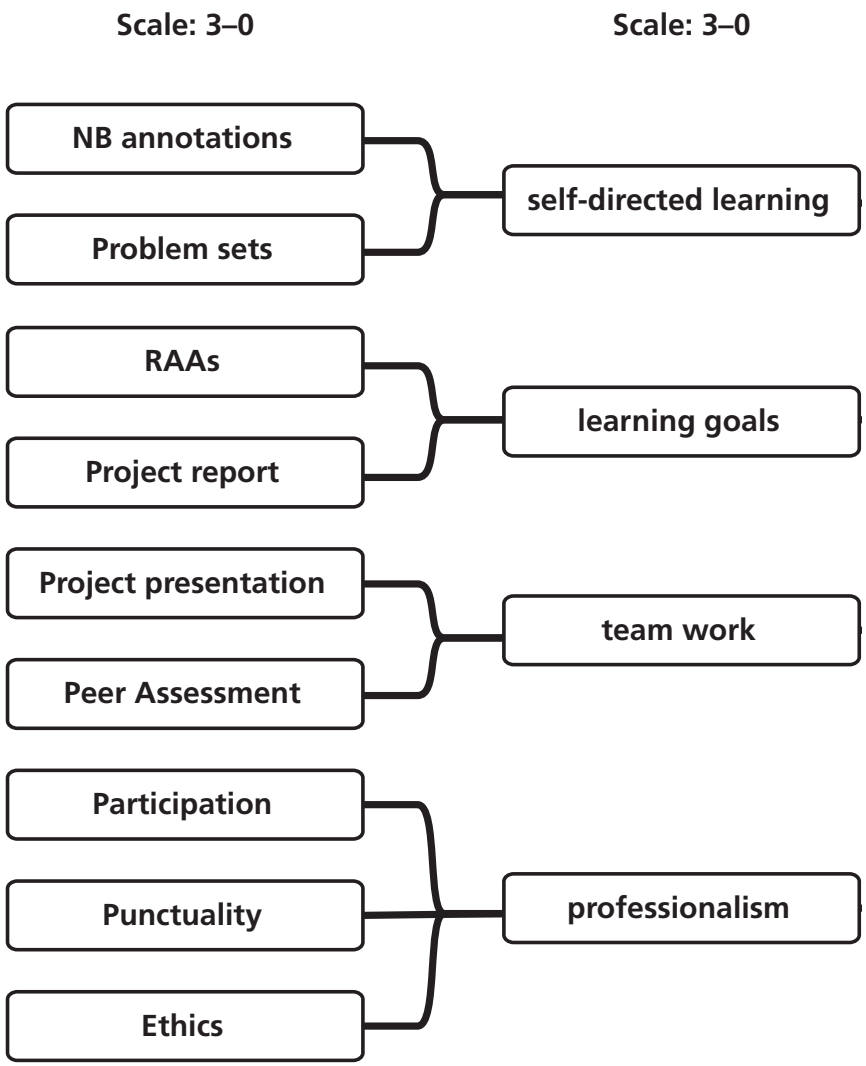
professionalism

Assessment

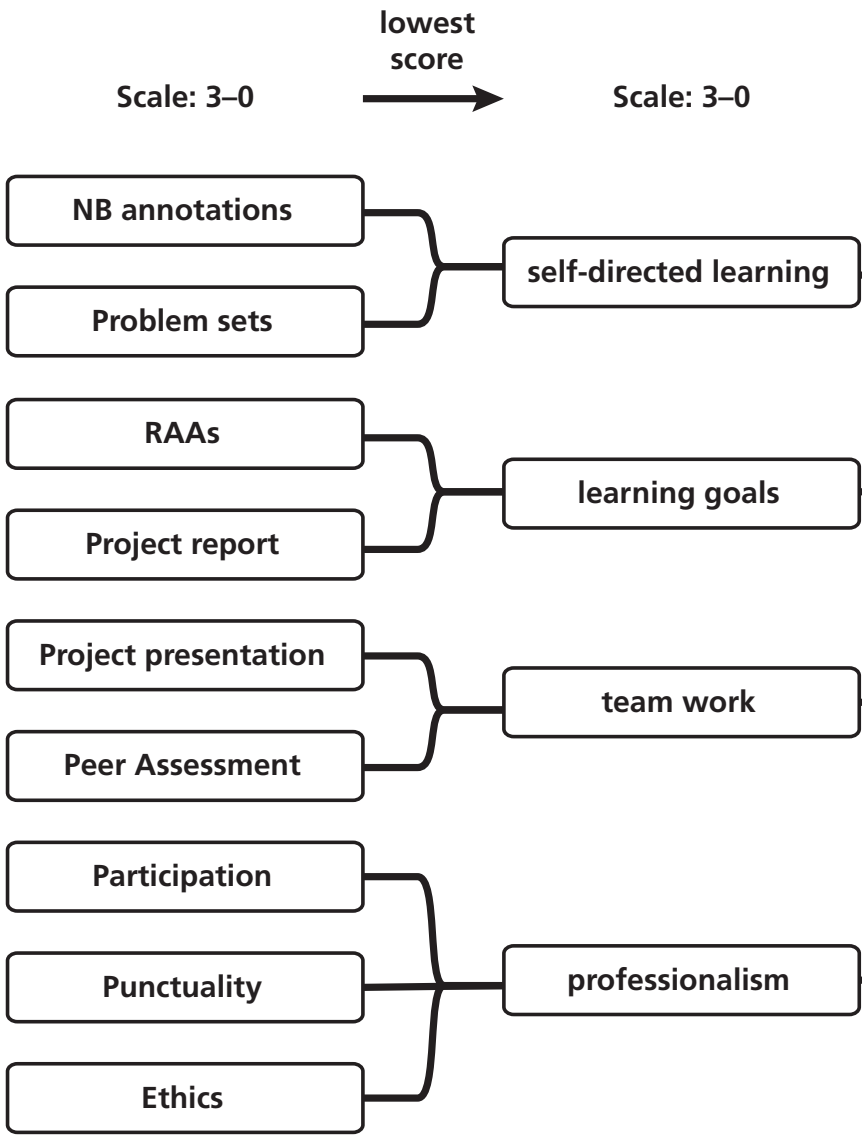
Scale: 3–0



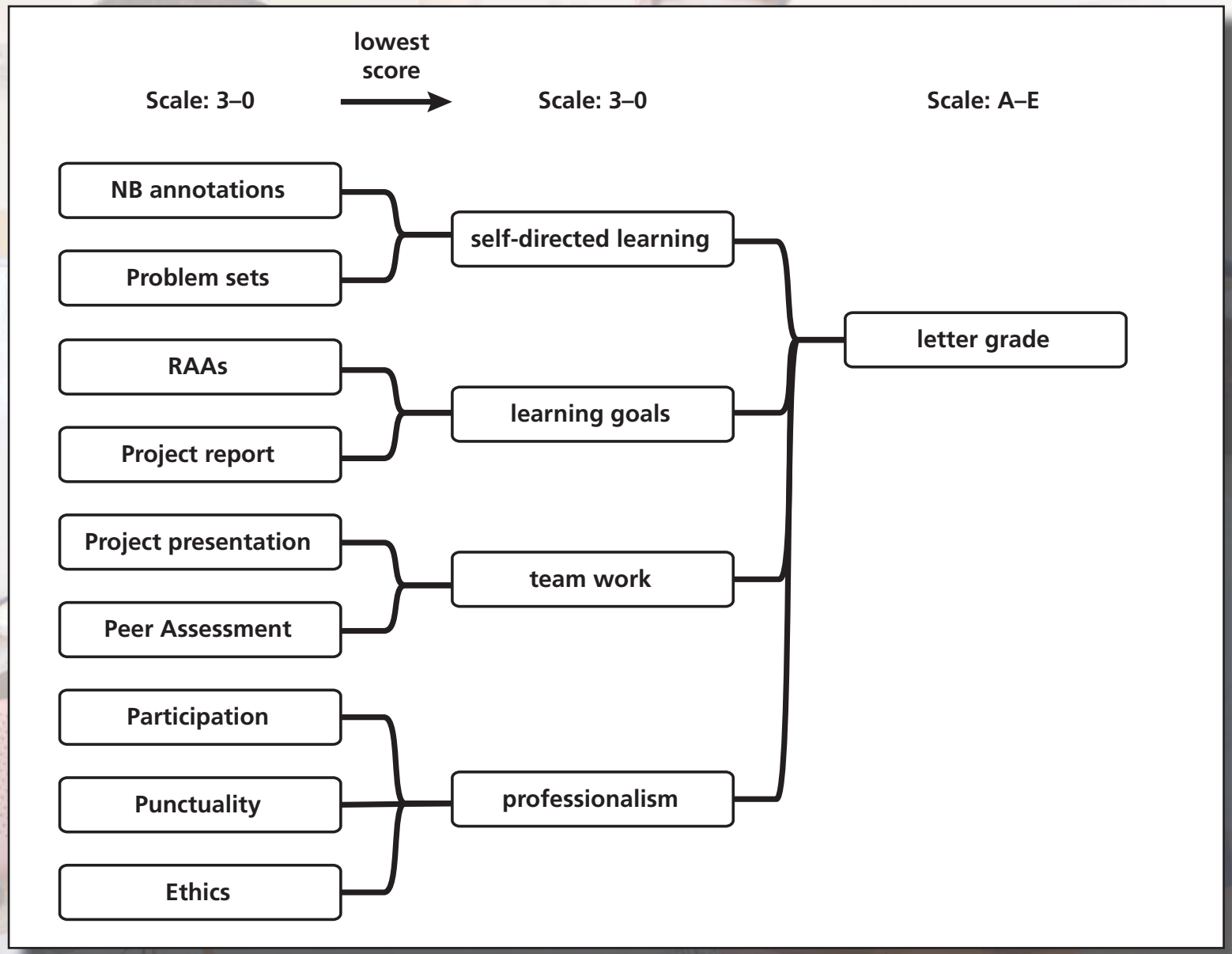
Assessment


Scale: 3–0
Scale: 3–0
NB annotations
Problem sets
self-directed learning
RAAs
Project report
learning goals
Project presentation
Peer Assessment
team work
Participation
Punctuality
Ethics
professionalism

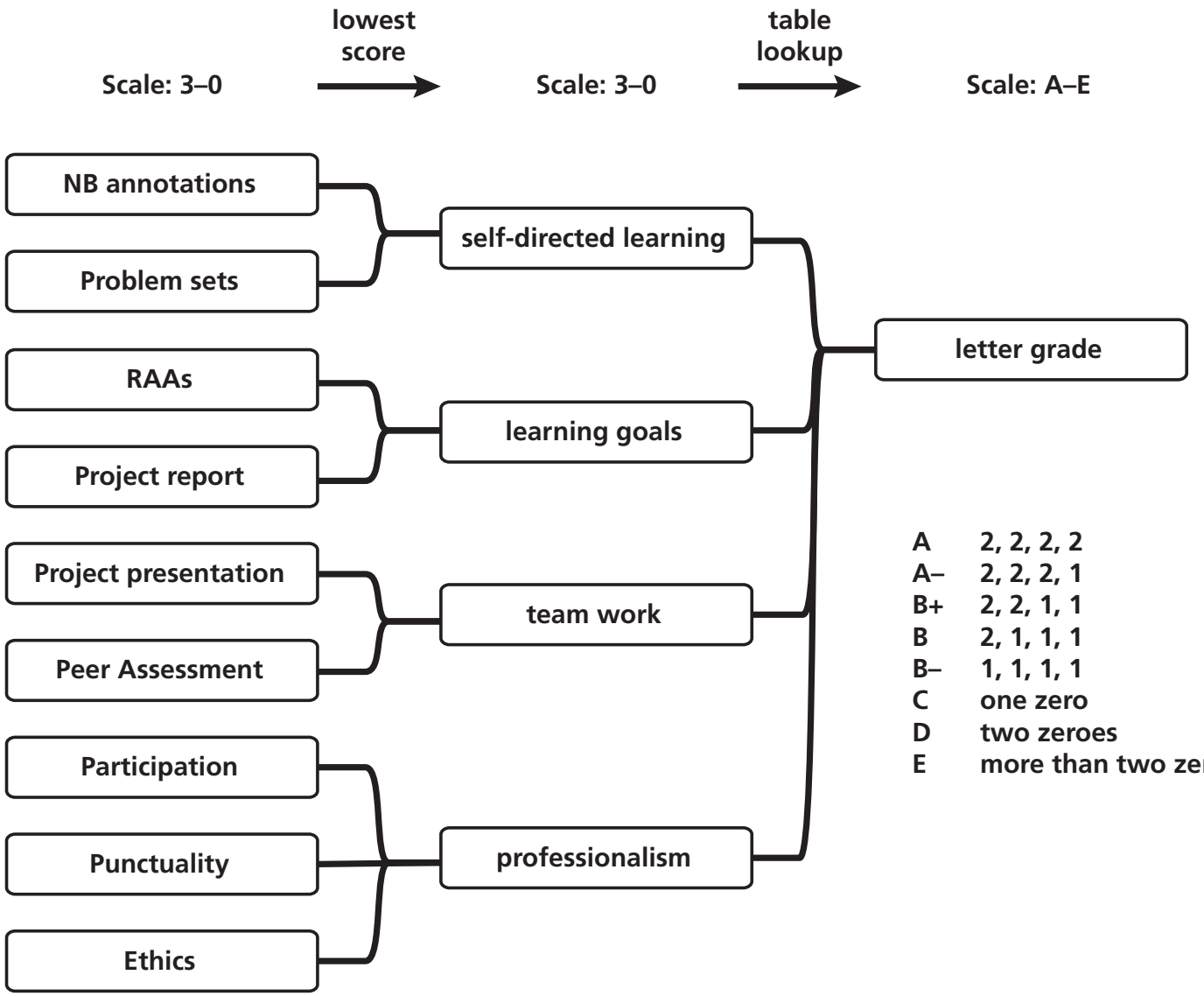
Assessment


lowest score
Scale: 3–0
Scale: 3–0
NB annotations
Problem sets
self-directed learning
RAAs
Project report
learning goals
Project presentation
Peer Assessment
team work
Participation
Punctuality
Ethics
professionalism

Assessment


lowest score
Scale: 3–0
Scale: 3–0
Scale: A–E
NB annotations
Problem sets
RAAs
Project report
Project presentation
Peer Assessment
Participation
Punctuality
Ethics
self-directed learning
learning goals
team work
professionalism
letter grade

Assessment



A	2, 2, 2, 2
A–	2, 2, 2, 1
B+	2, 2, 1, 1
B	2, 1, 1, 1
B–	1, 1, 1, 1
C	one zero
D	two zeroes
E	more than two zeroes

1 design

2 approach

3 results

Ownership

1 design 2 approach 3 results

Ownership

Course evaluation: 4.2/5

Ownership

“The structure of the class made what was my least-favorite subject into one of my favorites.

Ownership

"The structure of the class made what was my least-favorite subject into one of my favorites. I was worried that people, including myself, would just slack off and do the bare minimum, but you really need to be on top of your readings and concepts in order to contribute to your team. GREAT CLASS!!!!!!"

Ownership

"Dear Harvard students, this class will be unlike any class you've taken at Harvard, and it will, hopefully, shift the entire foundation upon which you've based your education. I truly believe everyone should take this course; prepare to take full ownership of your learning."

Ownership

Attendance: 94% (AP50a), 97% (AP50b)

Ownership

Attendance: 94% (AP50a), 97% (AP50b)

3 hours and they don't *leave*!

Ownership

"I don't think I am well enough to make it through class. I feel terrible because I don't want to let my team down by not being there, but I don't think I'd be very helpful in my current state."

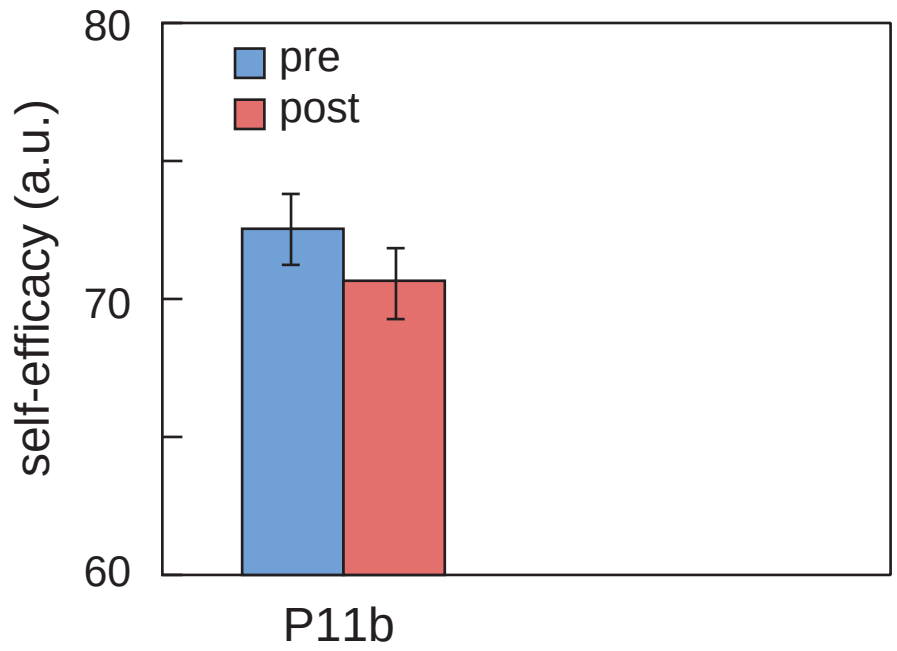
(via email)

Self-efficacy

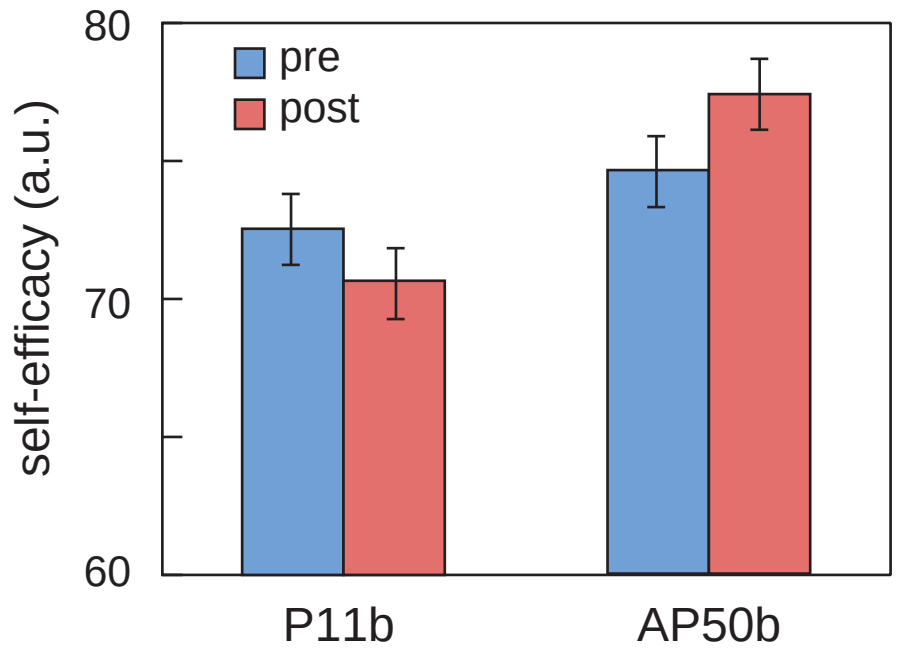
Self-efficacy

(students' belief in their ability to succeed)

Self-efficacy



Self-efficacy



Self-directed learning

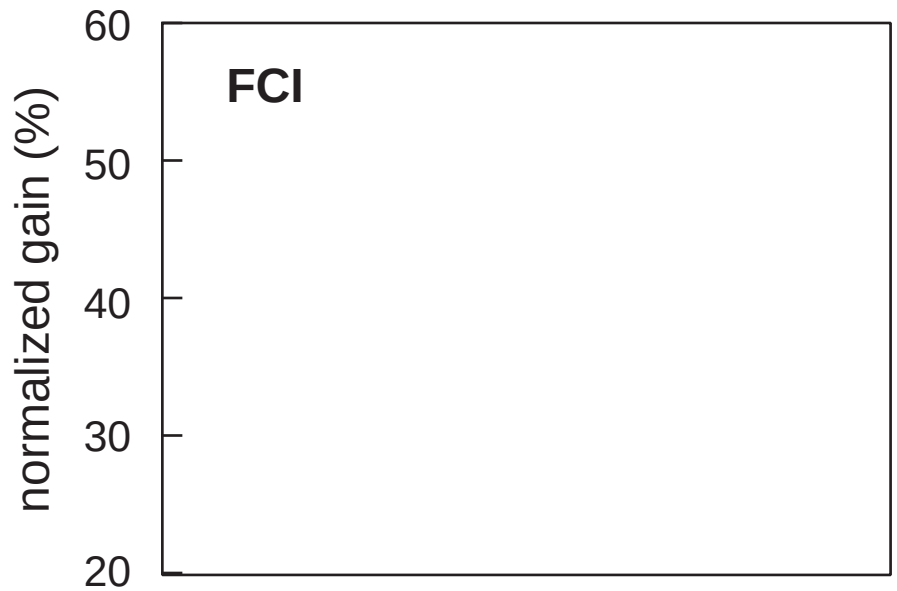
1 design 2 approach 3 results

Self-directed learning

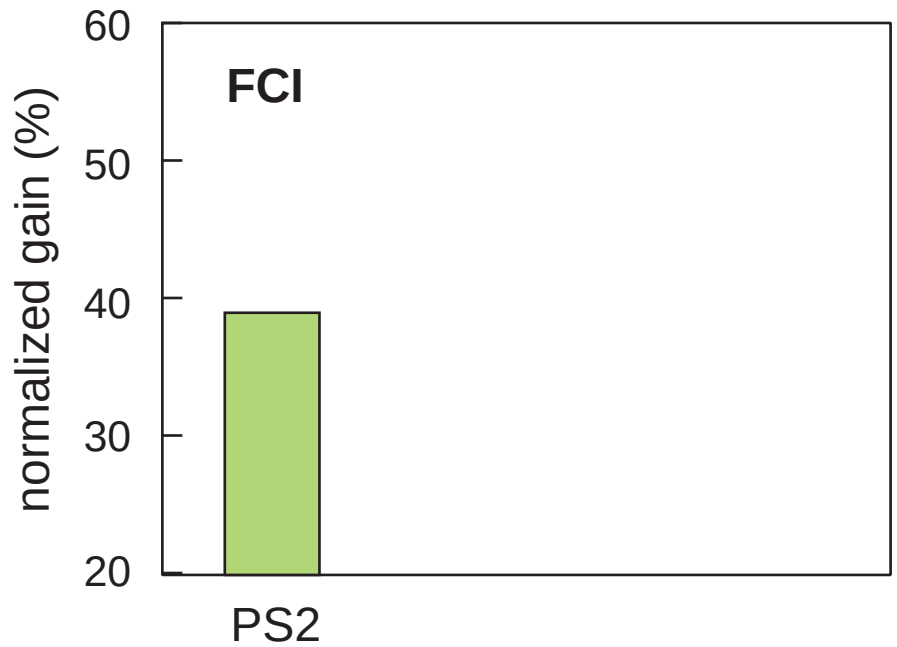
NB data shows:

- student spend on average 2.3 hrs/chapter
- 600–700 annotations/chapter (8–10/stu)

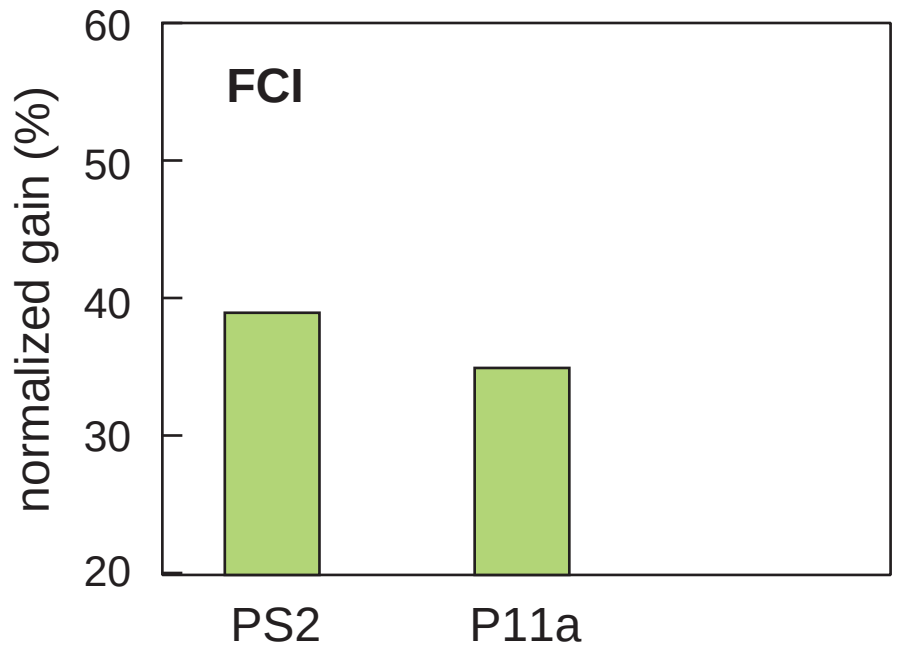
Conceptual Mastery



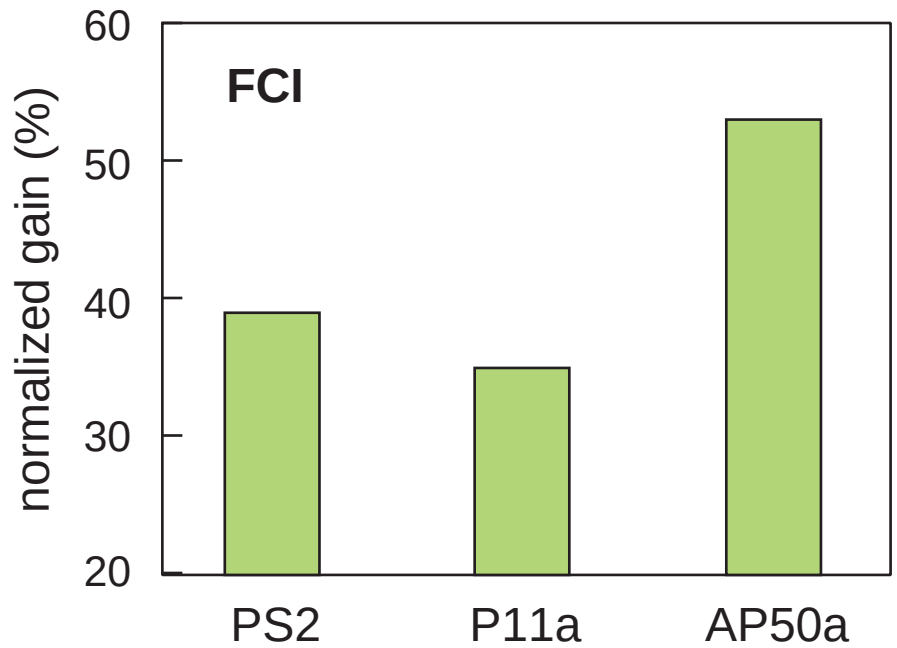
Conceptual Mastery



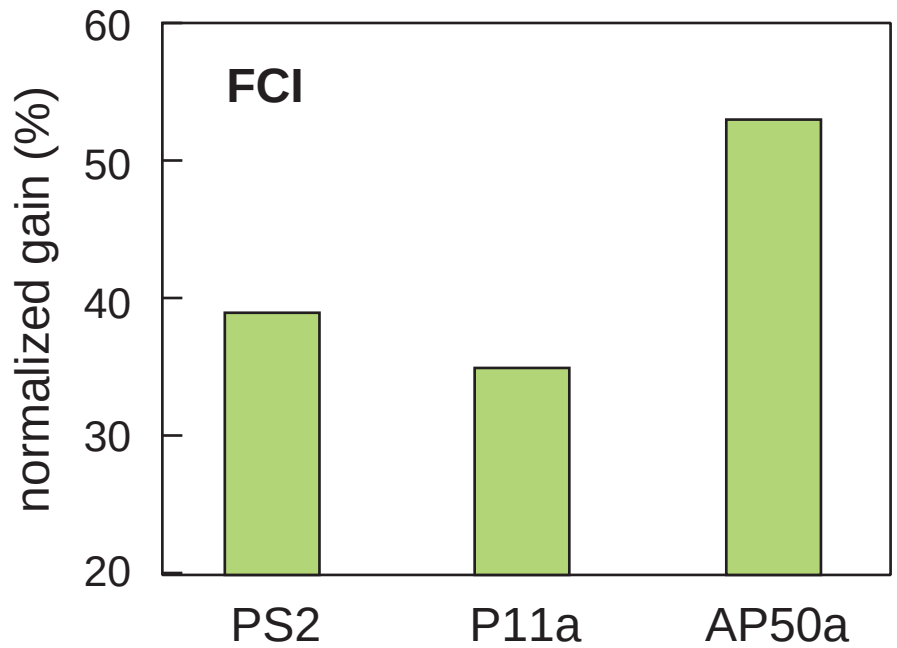
Conceptual Mastery



Conceptual Mastery

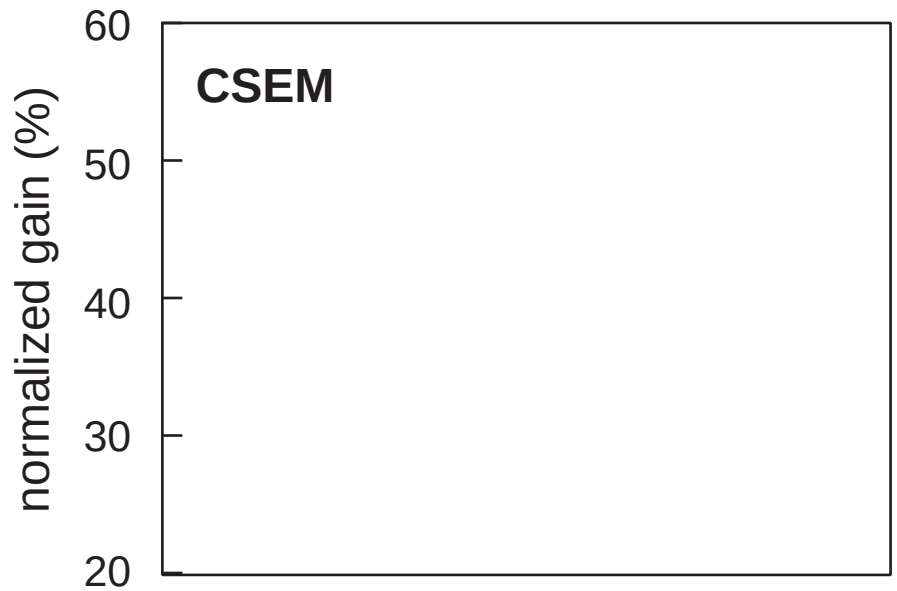


Conceptual Mastery

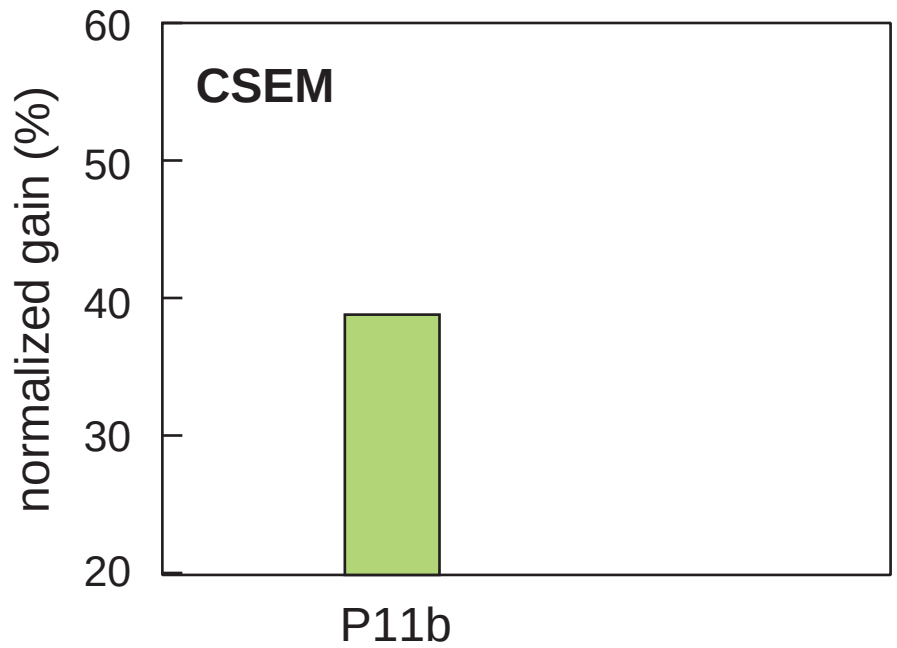


largest conceptual gain in *any* course past 6 yrs!

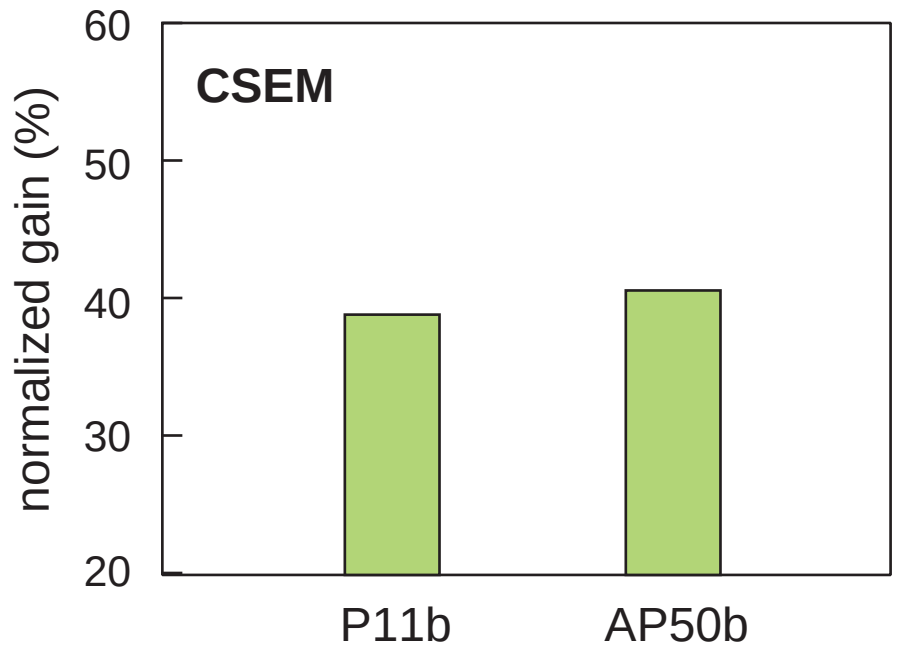
Conceptual Mastery



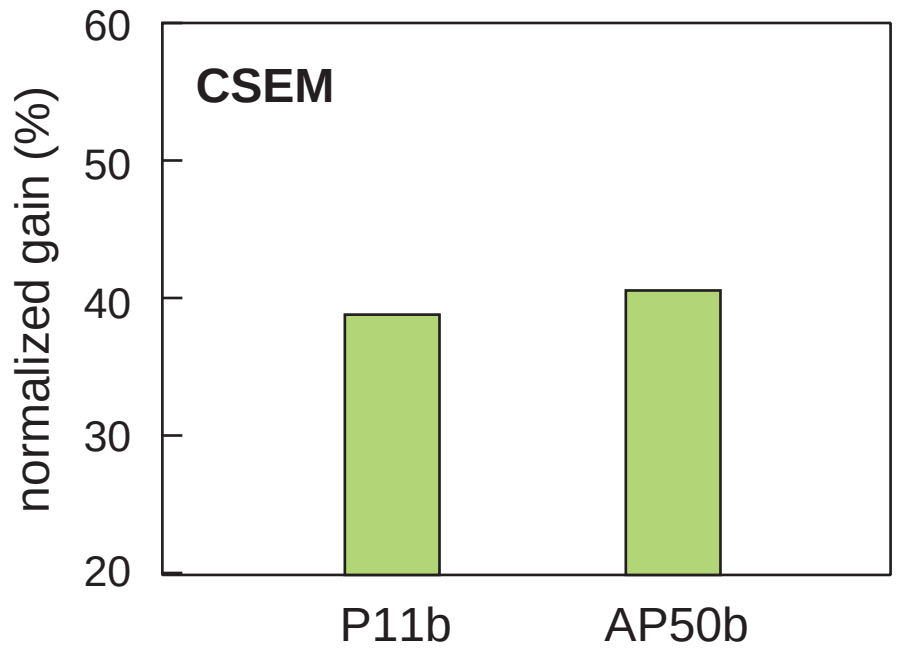
Conceptual Mastery



Conceptual Mastery



Conceptual Mastery



as good as when I do my best teaching!

1 design

2 approach

3 results

***Can* create ownership of learning physics!**

1 design 2 approach 3 results

Can create ownership of learning physics!

fun!

1 design 2 approach 3 results

"you come out with so much know-ledge and experience and fun"

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1 design 2 approach 3 results