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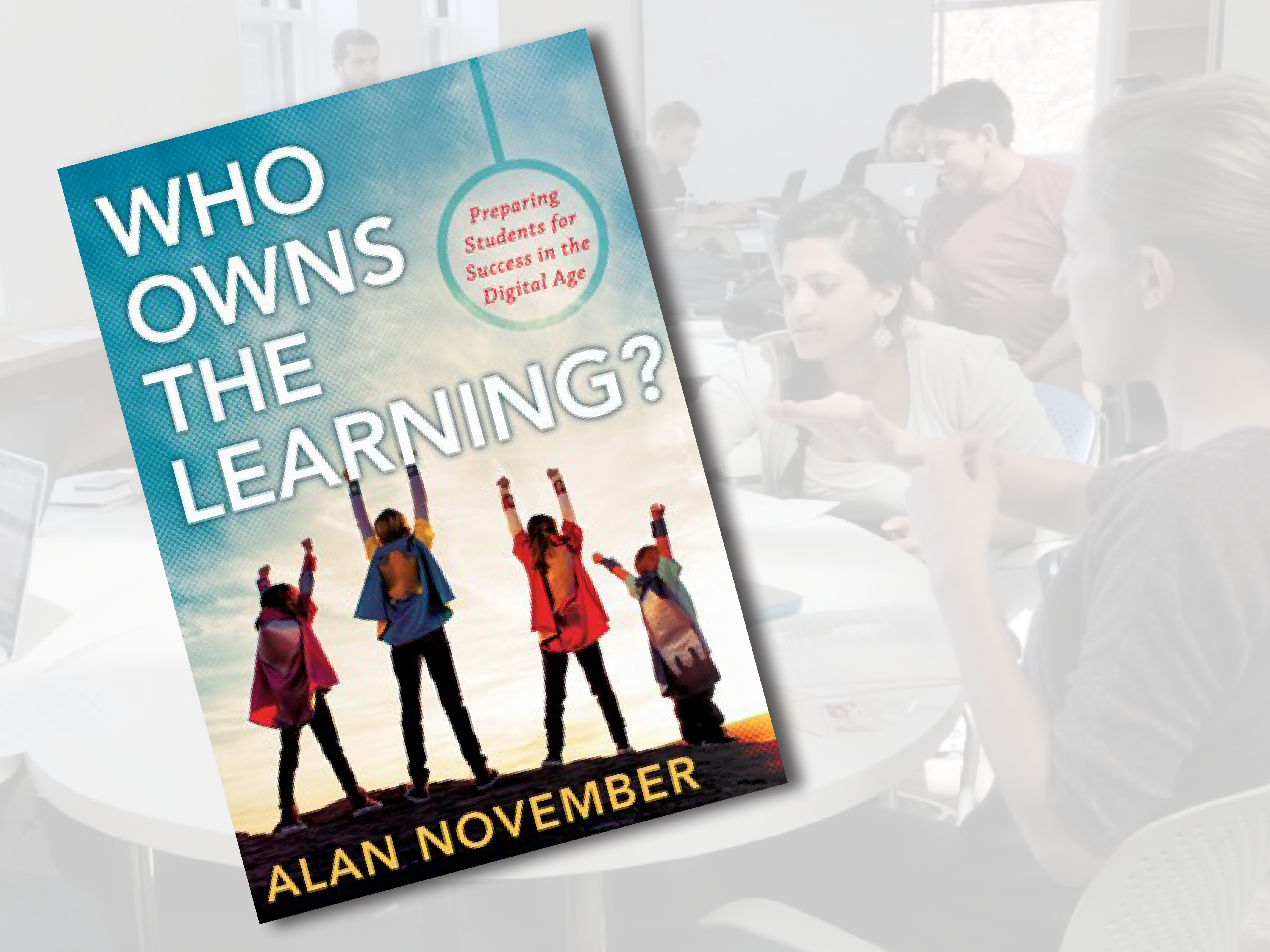
Flat space, deep learning

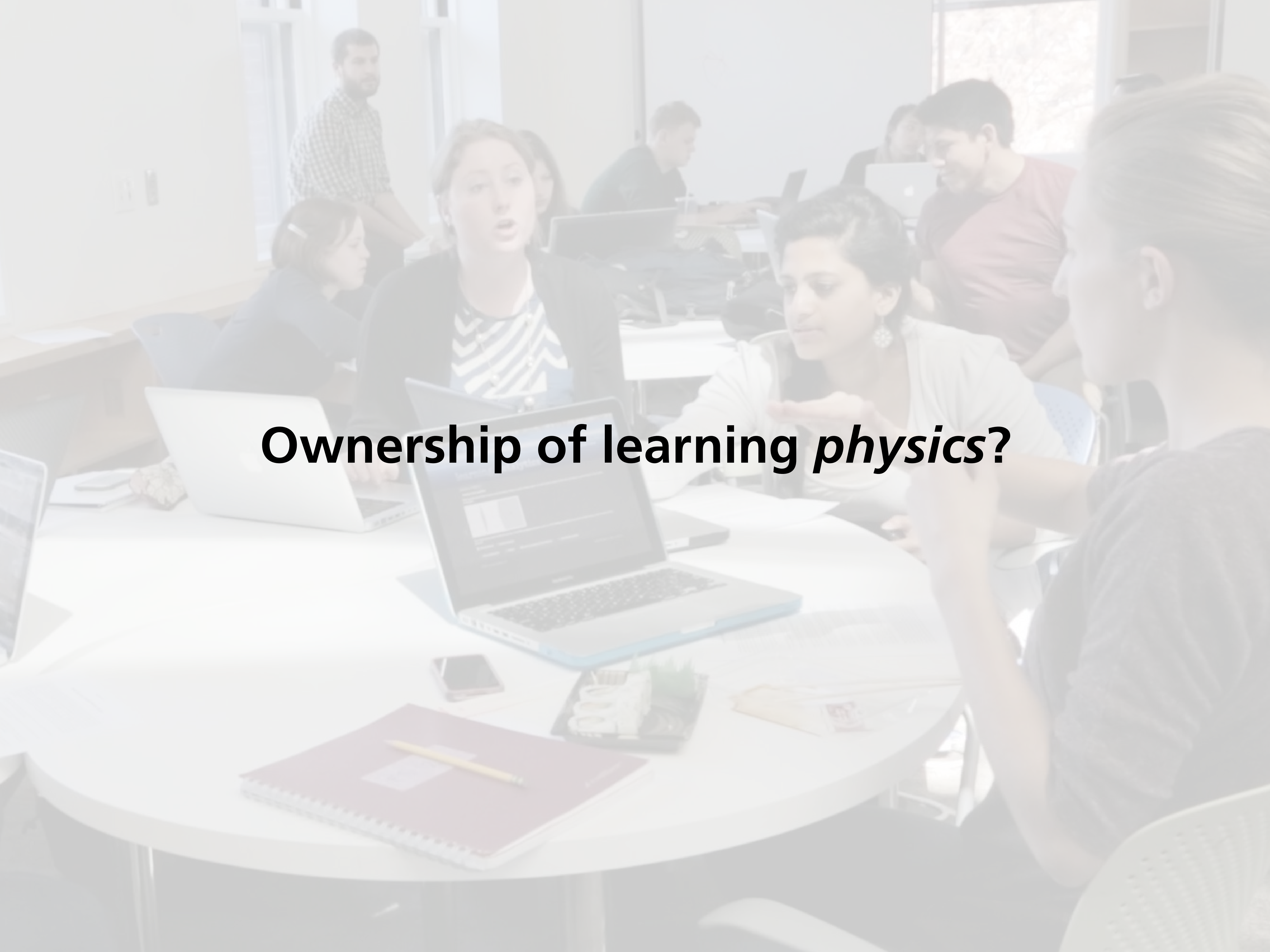
TU Delft
Delft, Netherlands, 24 November 2015

Flat space, deep learning

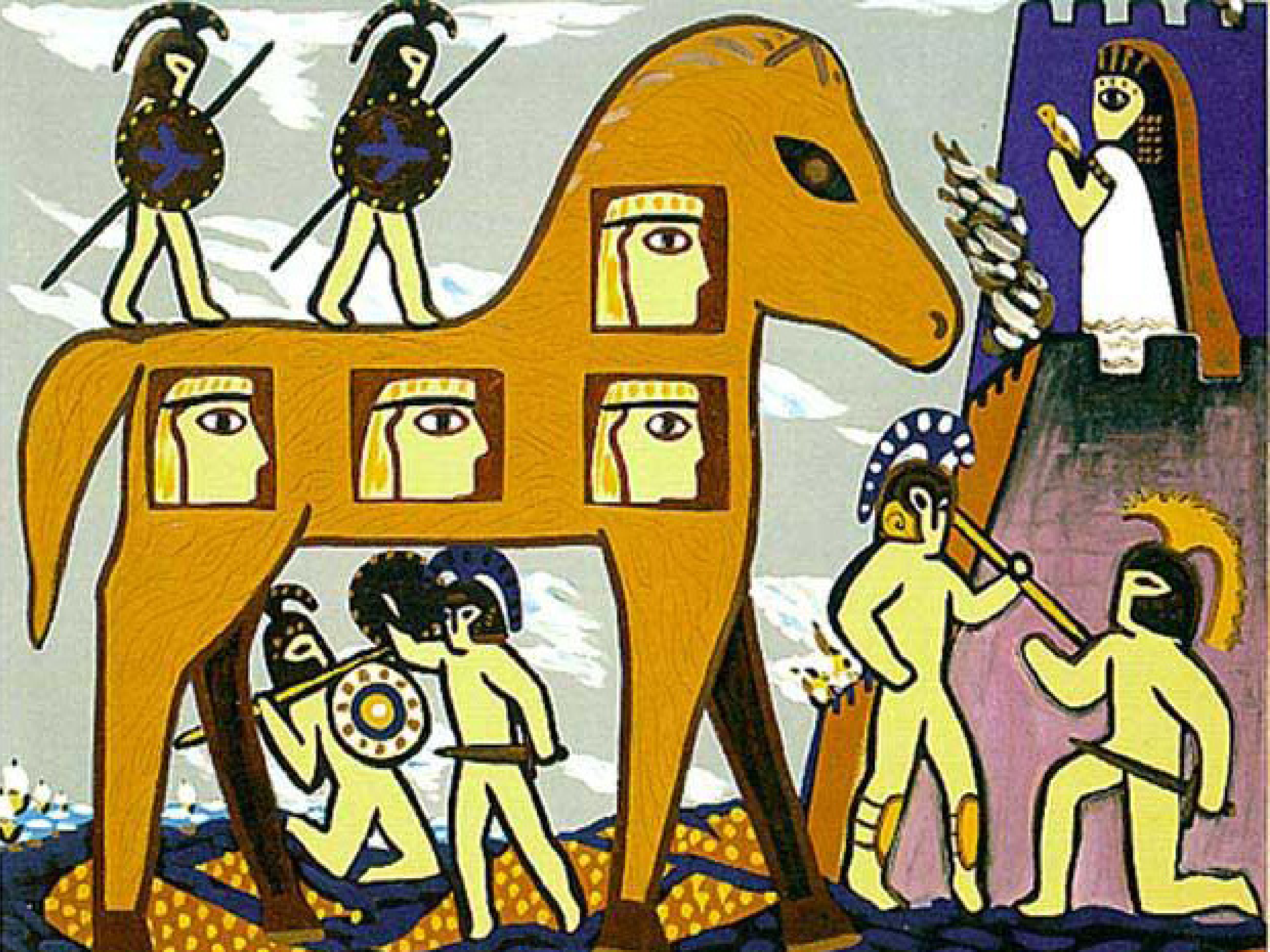
TU Delft

Delft, Netherlands, 24 November 2015

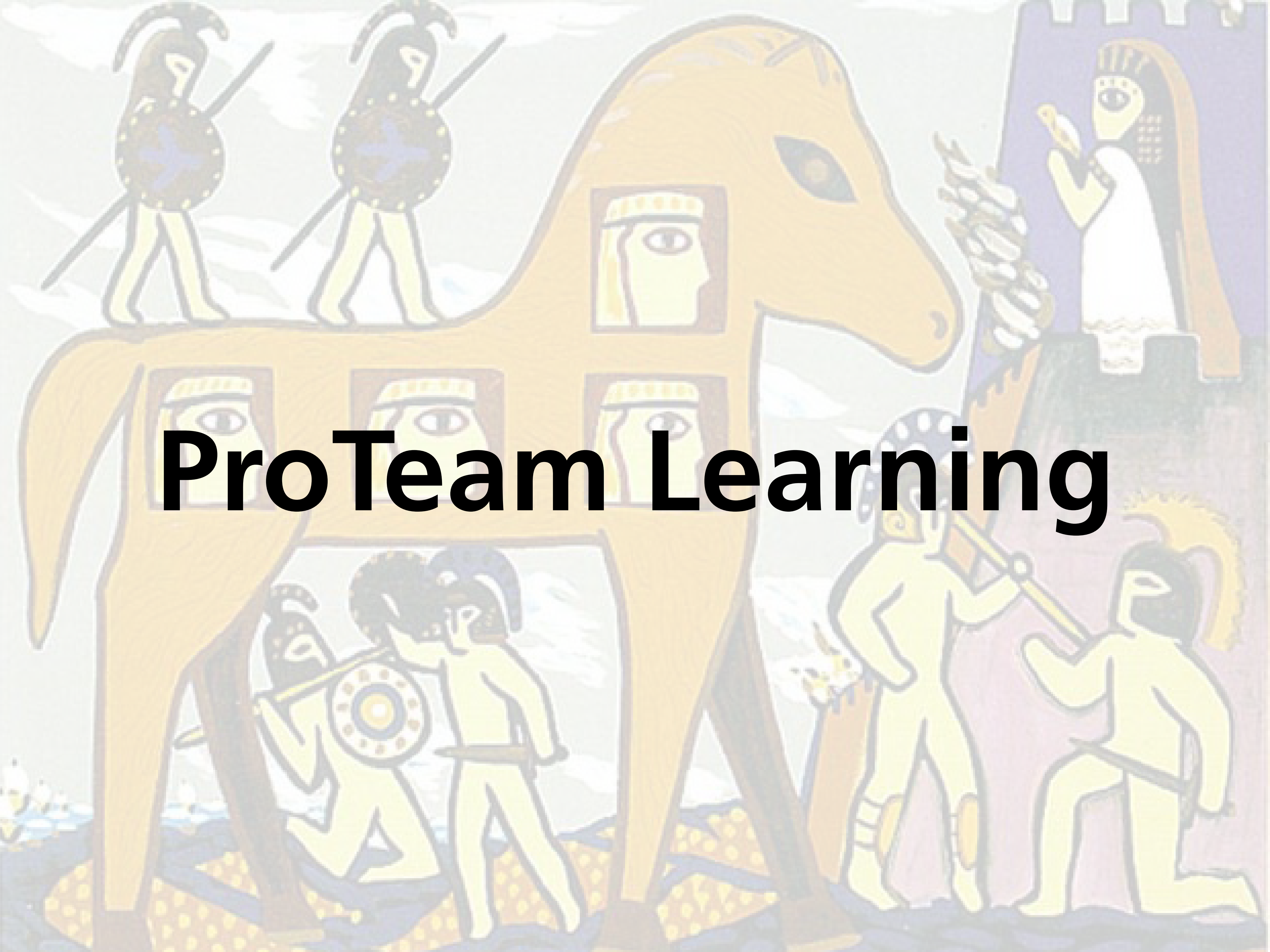

WHO
OWNS
THE
LEARNING?
Preparing Students for Success in the Digital Age
ALAN NOVEMBER



Ownership of learning *physics*?



team & project-based approach



ProTeam Learning

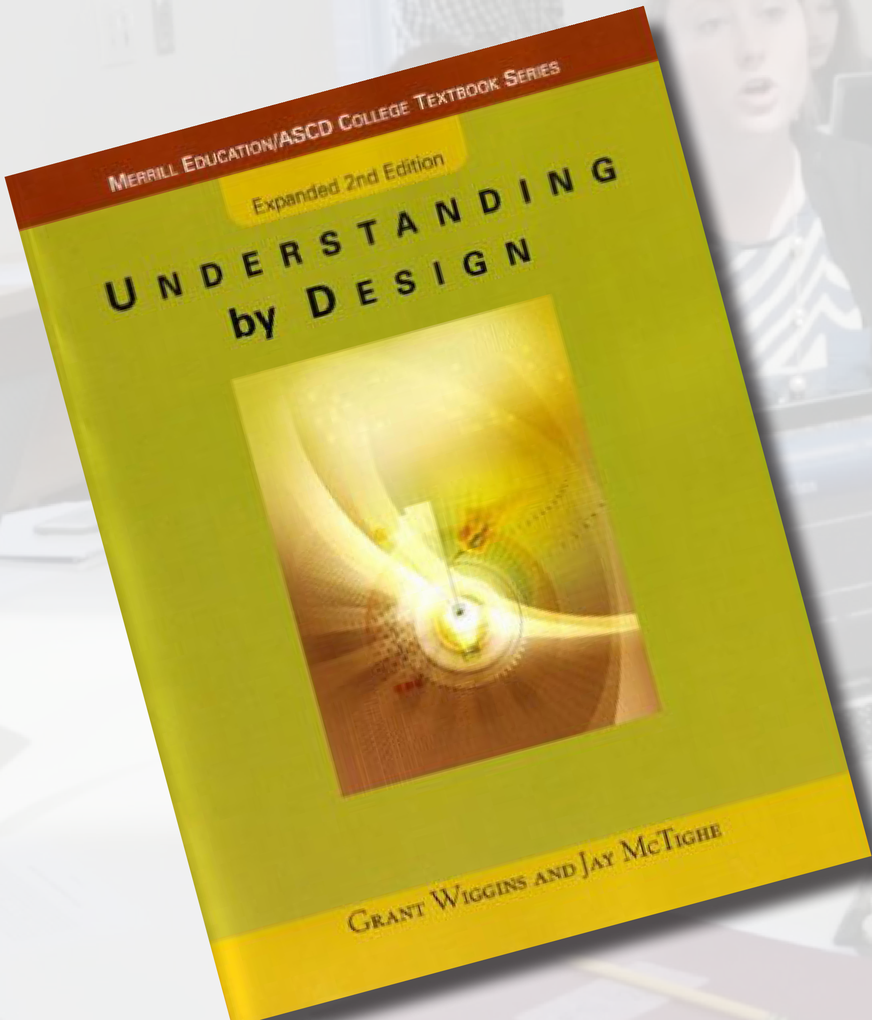
1 design

1 design

2 approach

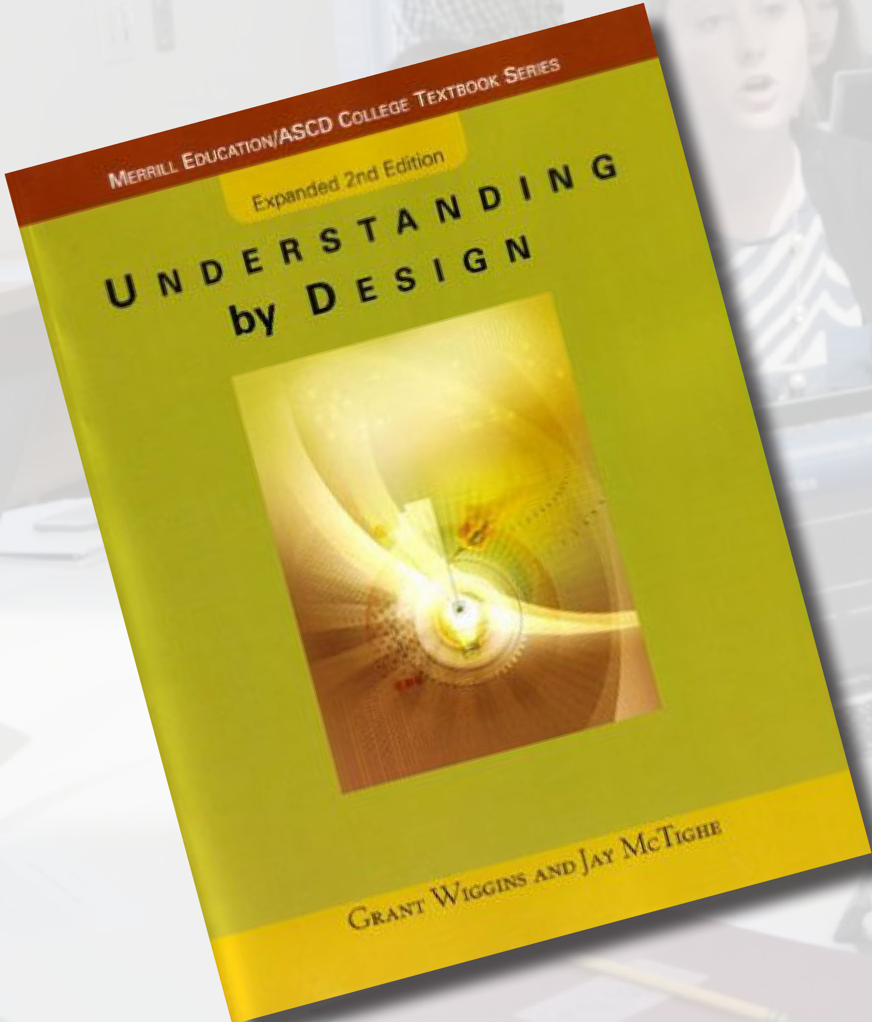
1 design 2 approach 3 results

Setting learning goals



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

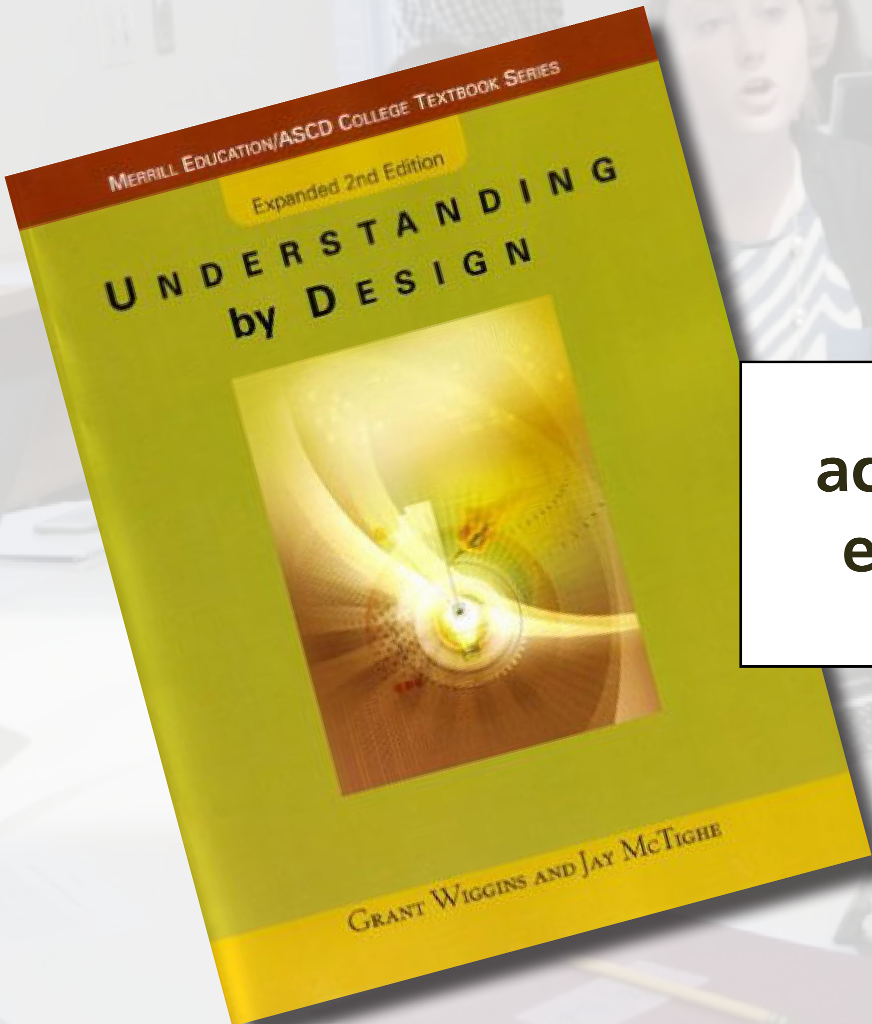
Backward design



desired outcomes

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

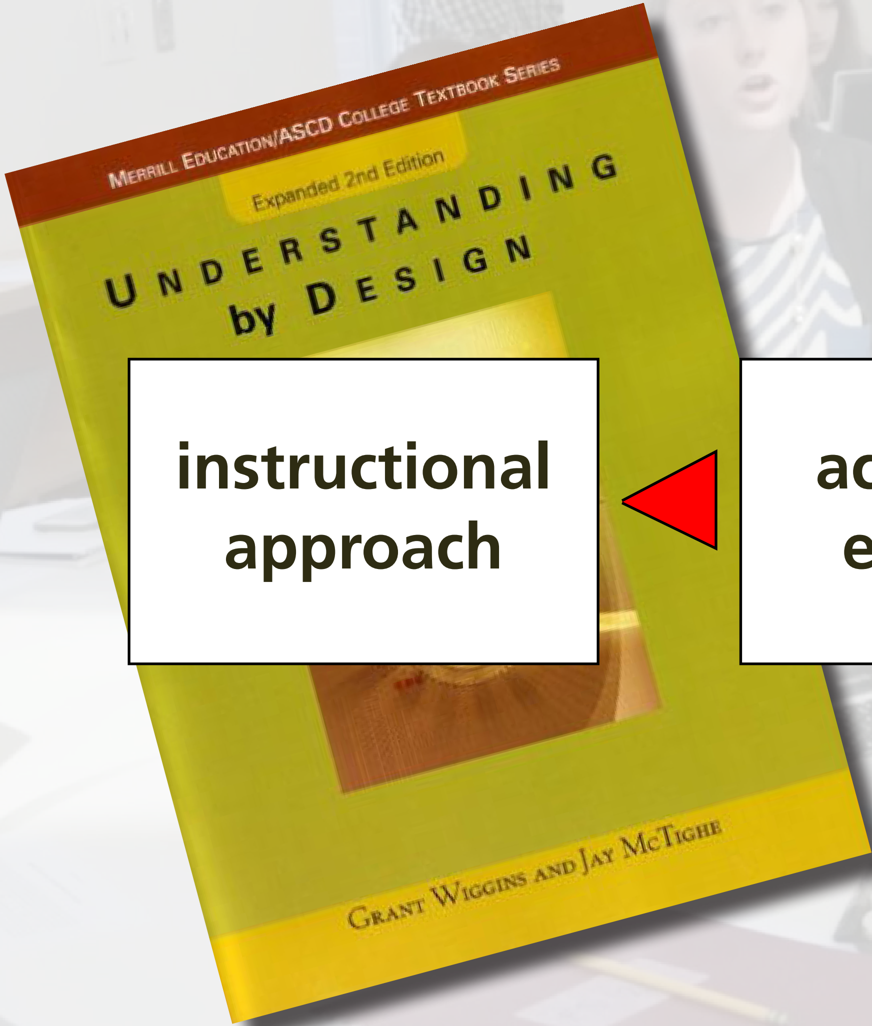
Backward design



acceptable evidence ◀ desired outcomes

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

Backward design



instructional approach ◀ acceptable evidence ◀ desired outcomes

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

competencies

course goals

COURSE GOALS

After successful completion of this course, yo

1. Engage in **self-directed learning** by:
   - identifying and addressing your own educational needs in a changing personal attributes, fluency in use of information sources, planning
   - using independent study and research to tackle problems, especial
   - using a variety of techniques to get a handle on problems: represe perform order-of-magnitude estimates, use dimensional analysis symmetries, evaluate limits, and/or relate the problem to cases
   - explaining and justify any assumptions made
   - "thinking critically," both positively and negatively, about any
   - evaluating the correctness of a solution
2. Demonstrate **content mastery** by:
   meeting the content learning goals specified in the project
   knowledge of physics to solve problems
   interpreting them

- **self-directed learning**
- **content mastery**
- **team work**
- **professionalism**

COURSE GOALS

After successful completion of this course, yo…

1. Engage in **self-directed learning** by:
- identifying and addressing your own educational needs in a changin…
- personal attribute… fluency in use of information sources, planning…
- using independent study and research to tackle problems, especial…
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- explaining and justify any assumptions made
- "thinking critically," both positively and negatively, about any
- evaluating the correctness of a solution

2. Demonstrate **content mastery** by:
- meeting the content learning goals specified in the project
- …knowledge of physics to solve problems
- …interpreting them

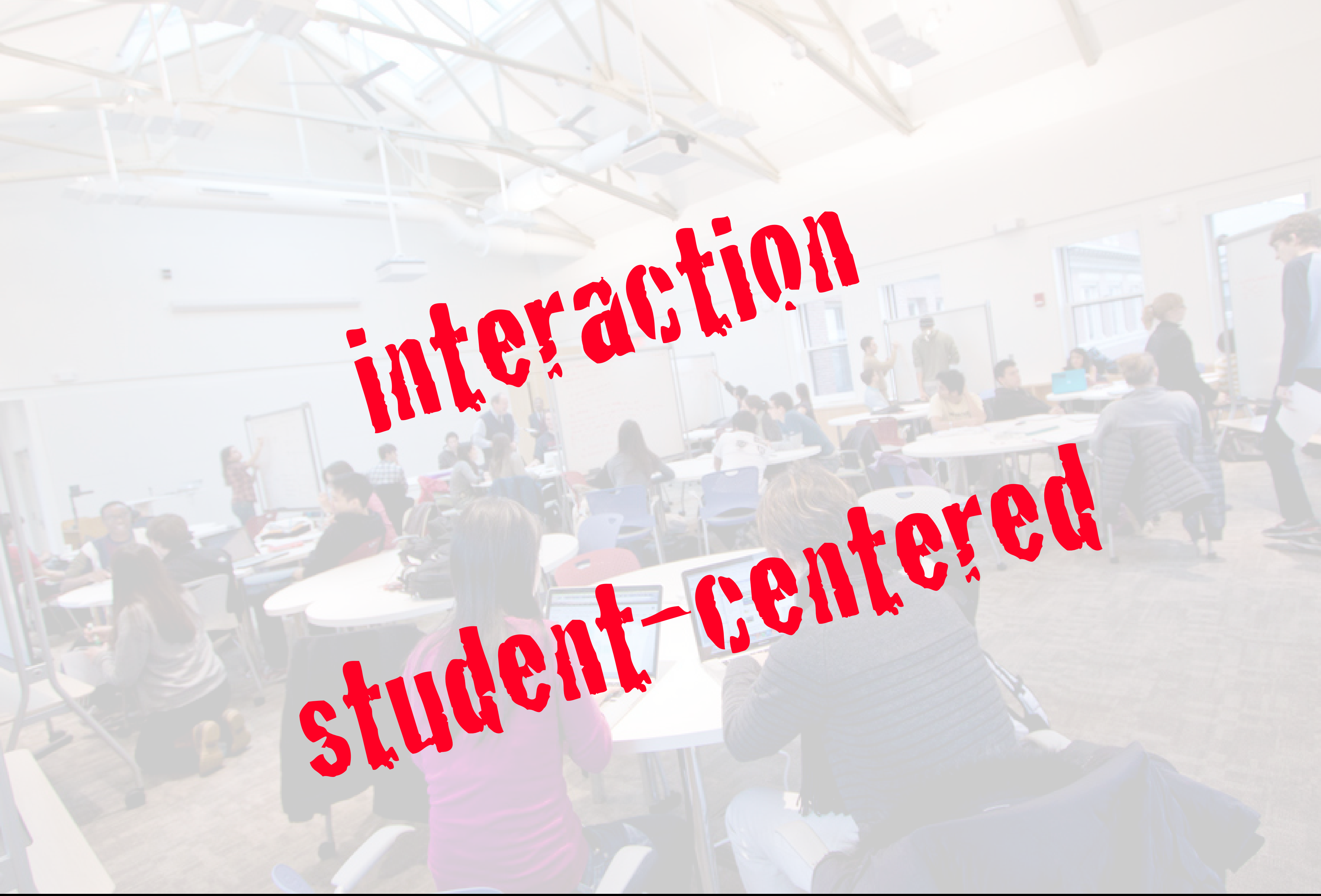
content-specific goals

http://bit.ly/ap50visitor

1 design

1 design

1 design



1 design

1 design

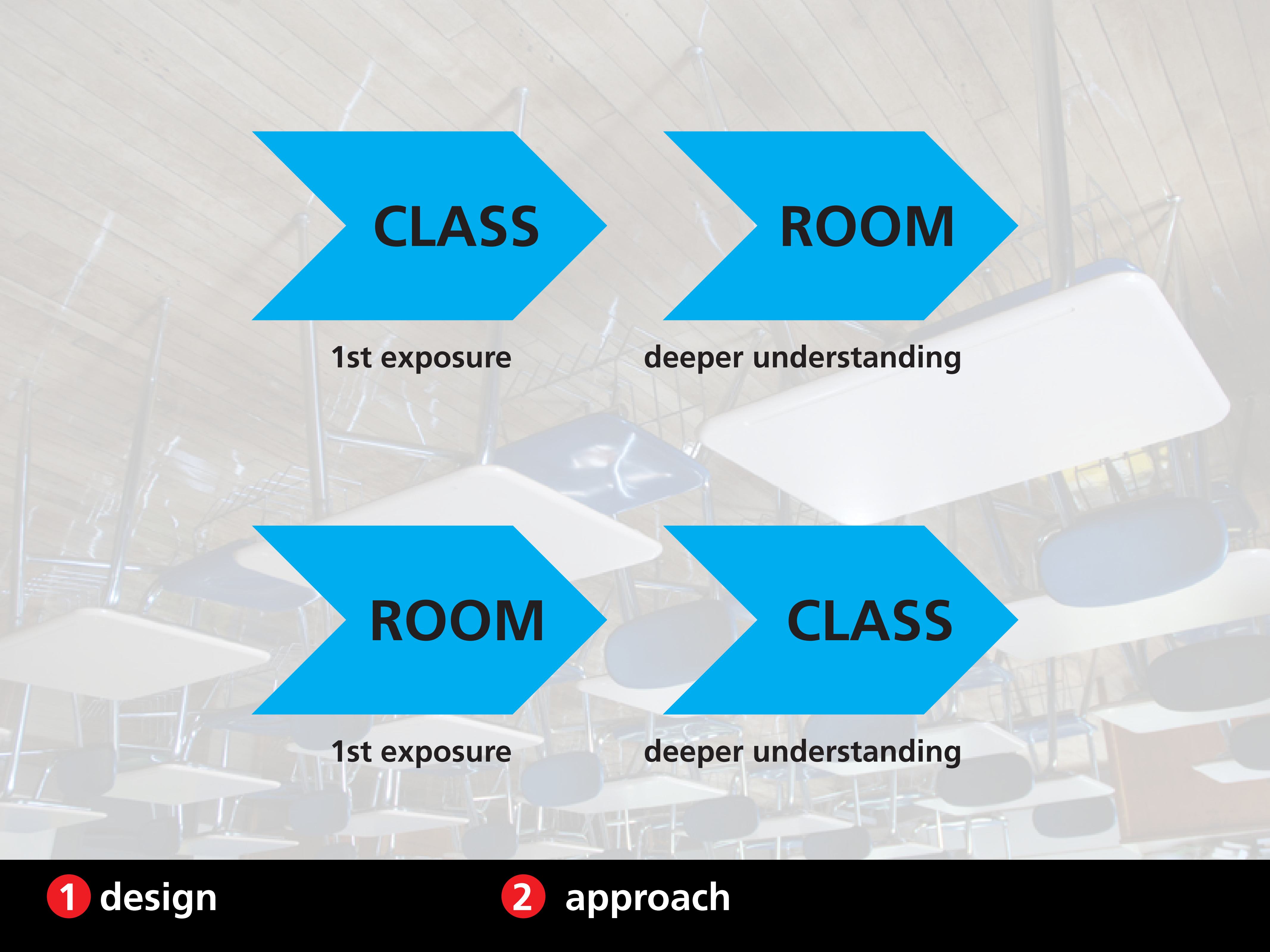
2 approach

CLASS → **ROOM**

1st exposure → deeper understanding

1 design

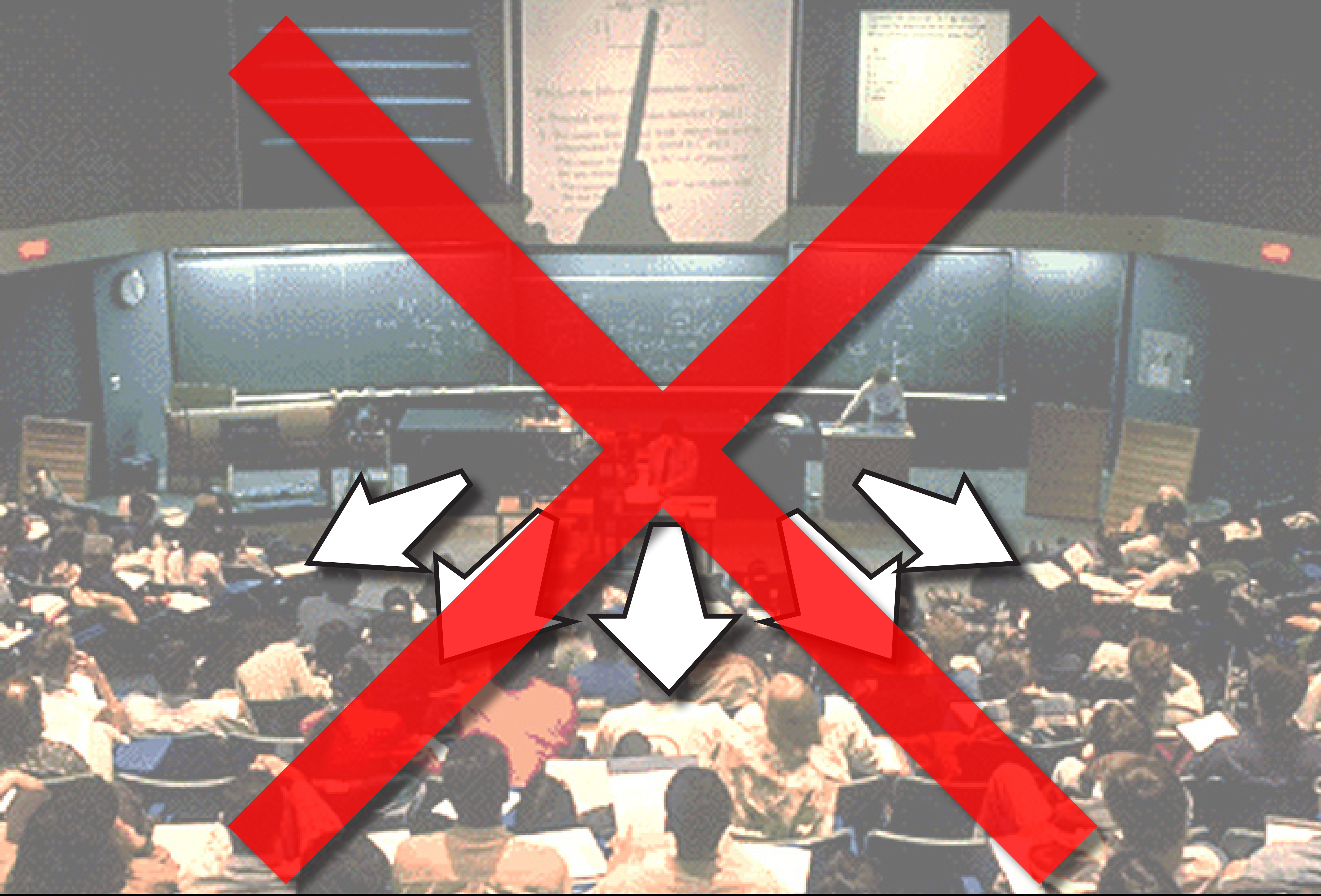
2 approach


CLASS
ROOM
1st exposure
deeper understanding
ROOM
CLASS
1st exposure
deeper understanding
1 design
2 approach

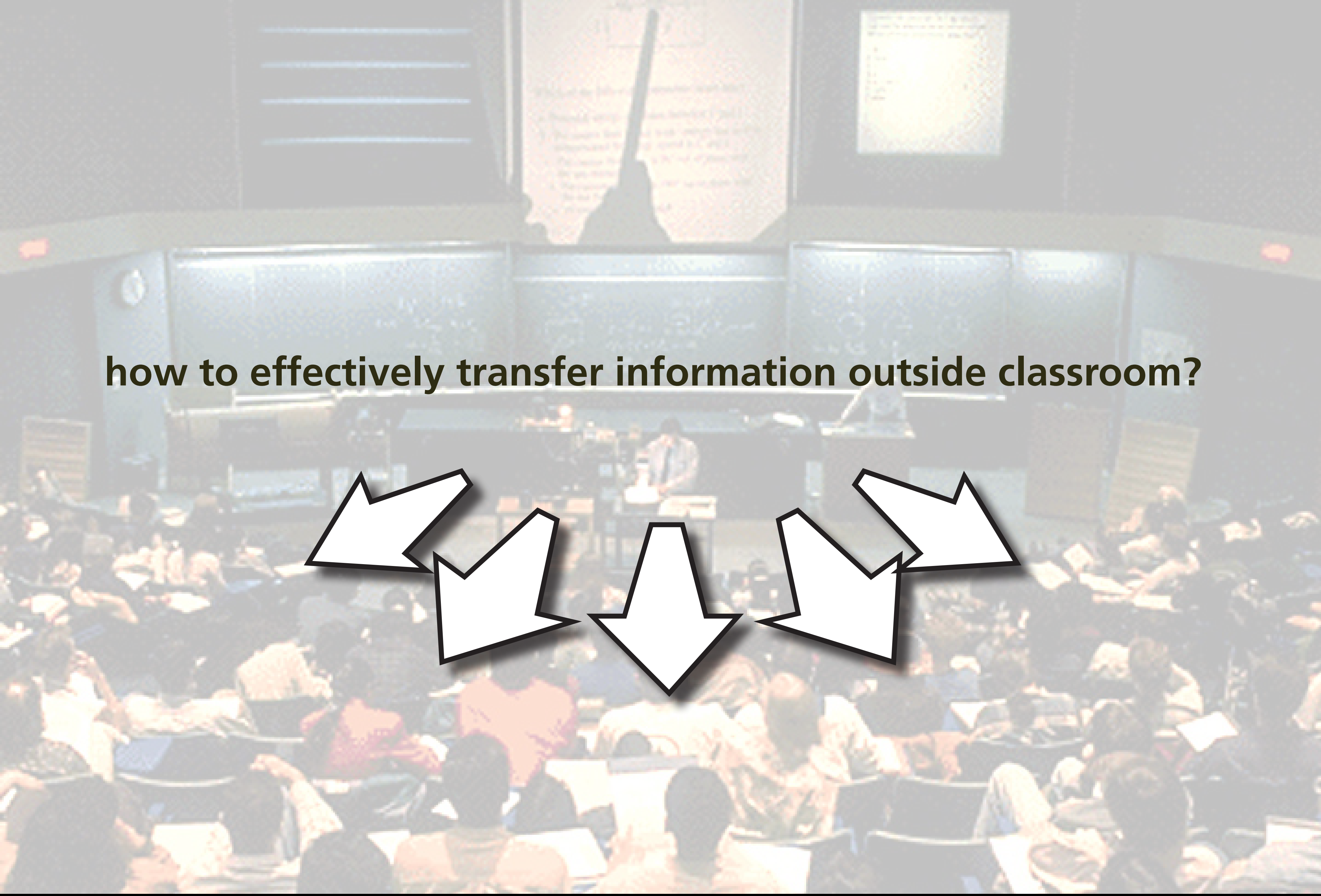
❶ design ❷ approach

Three major components:

- information transfer (out of class)
- projects
- in-class activities



❶ **design** ❷ **approach**



1 design

2 approach

1 design

2 approach

1 design

2 approach

- transfer pace set by video
- viewer passive
- viewing/attention tanks as time passes
- isolated/individual experience

1 design

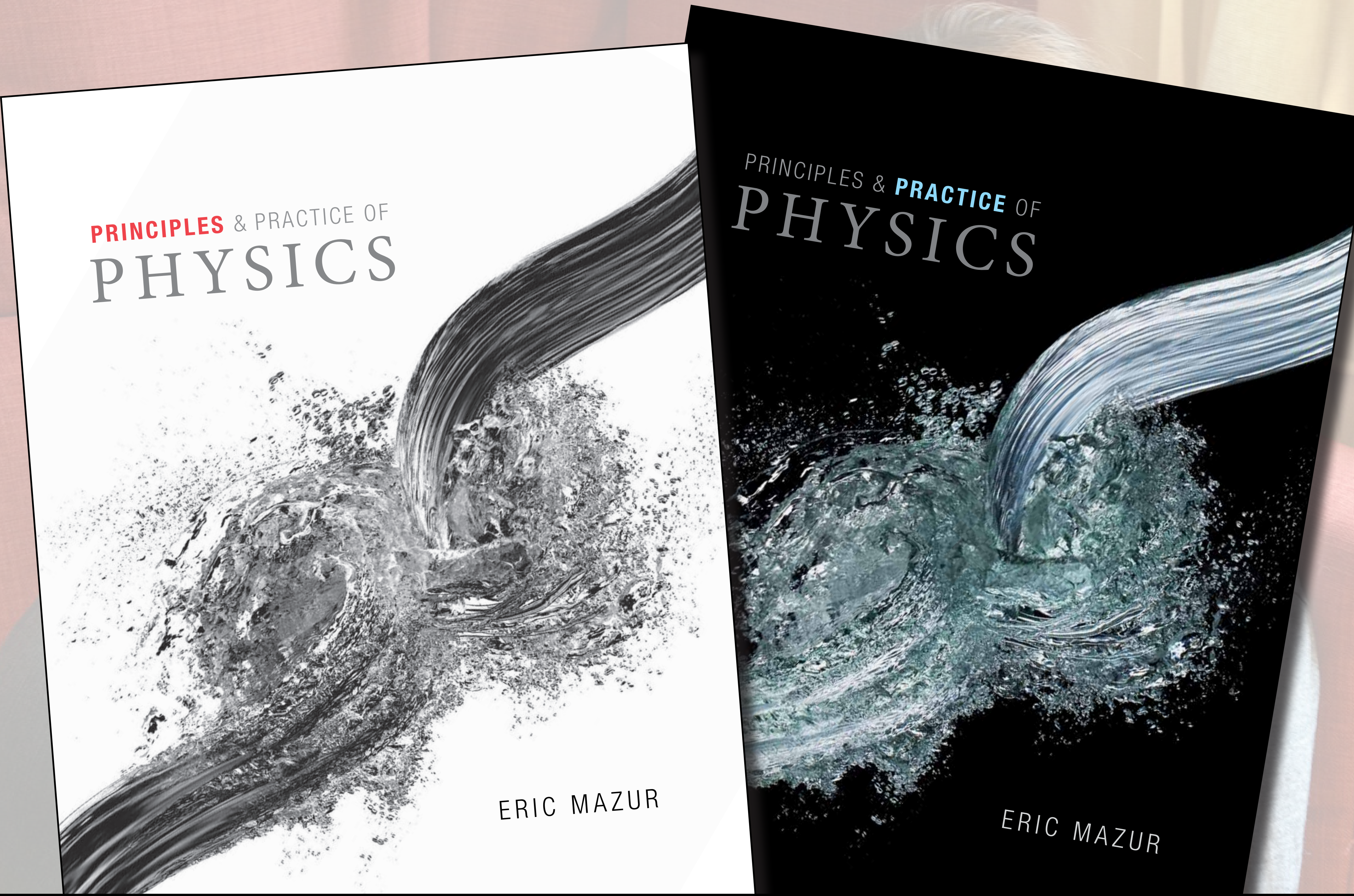
2 approach

we’re simply moving this outside classroom!

1 design 2 approach

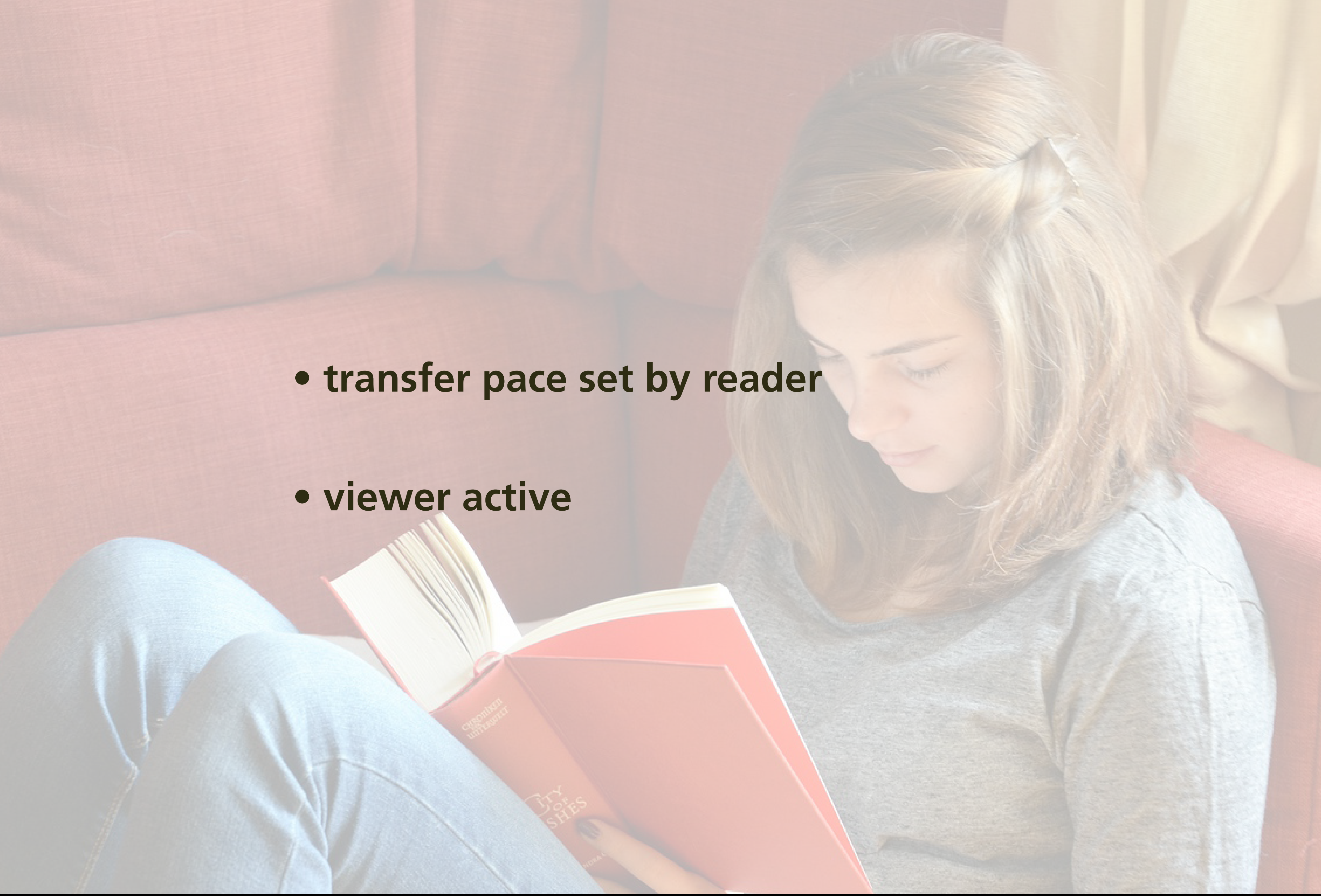
1 **design**

2 **approach**



1 design

2 approach



- transfer pace set by reader
- viewer active

but…

❶ **design** ❷ **approach**

isolated/individual experience &

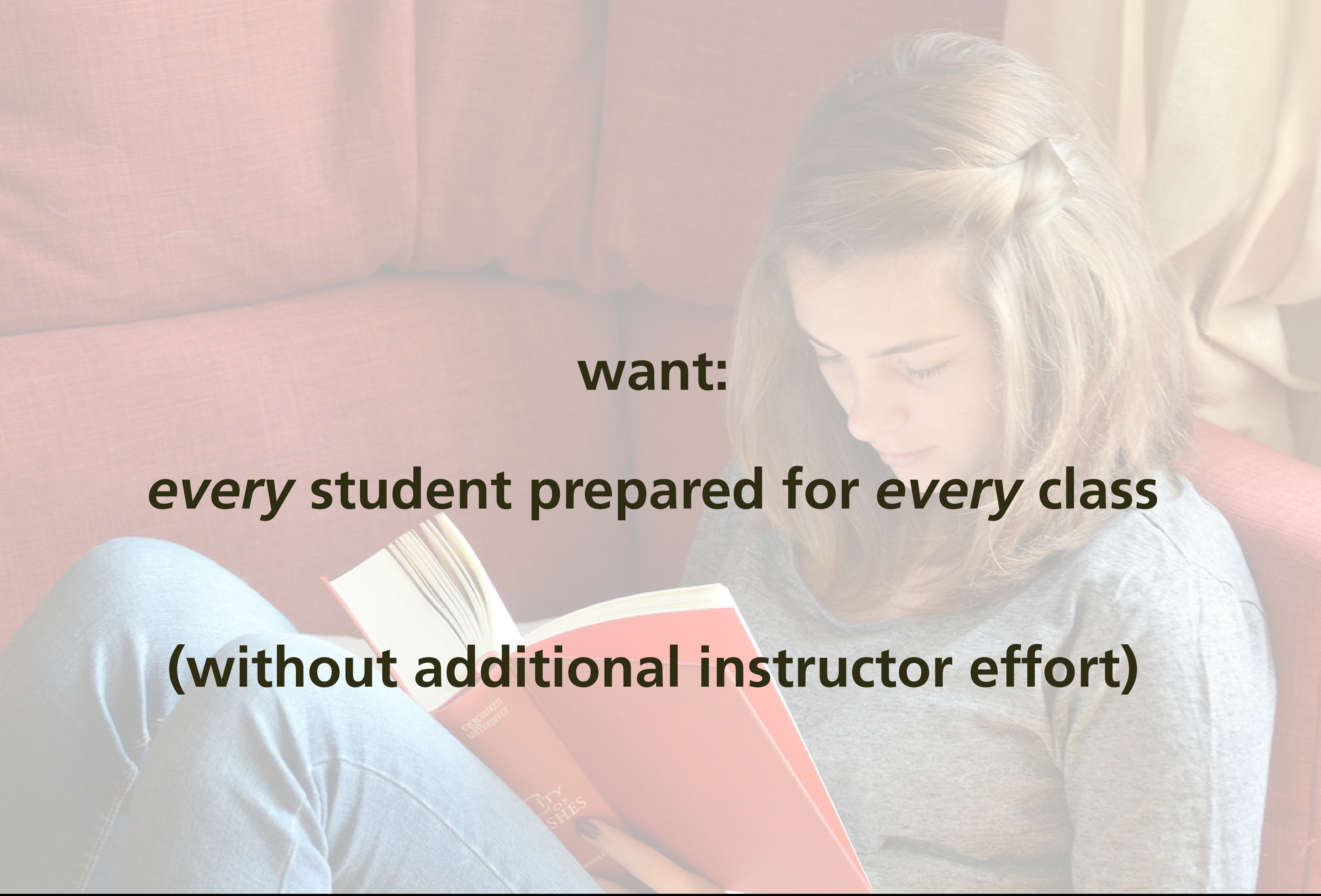
no real accountability

❶ design ❷ approach

want:

every student prepared for *every* class

❶ design ❷ approach

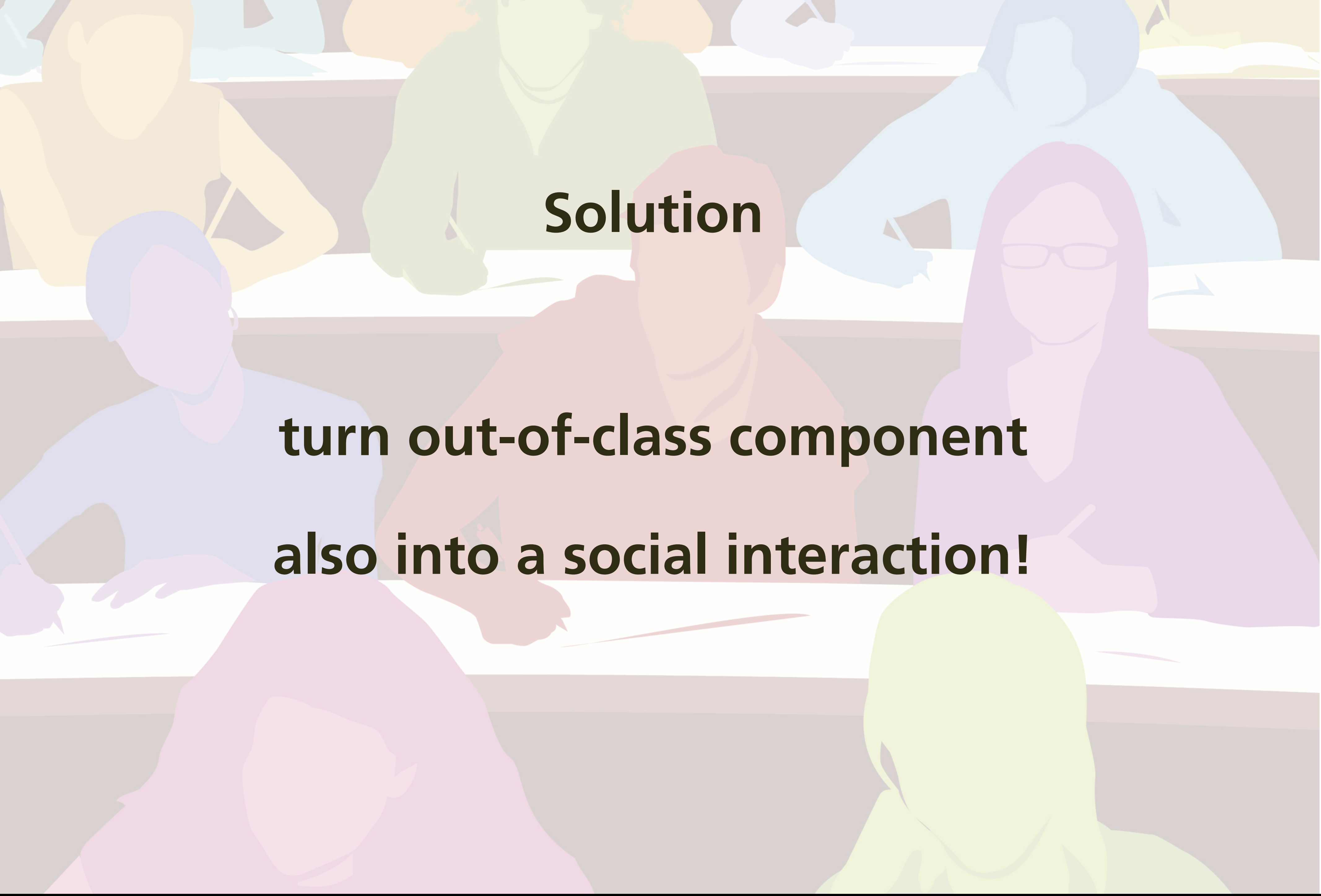


want:

every student prepared for *every* class

(without additional instructor effort)

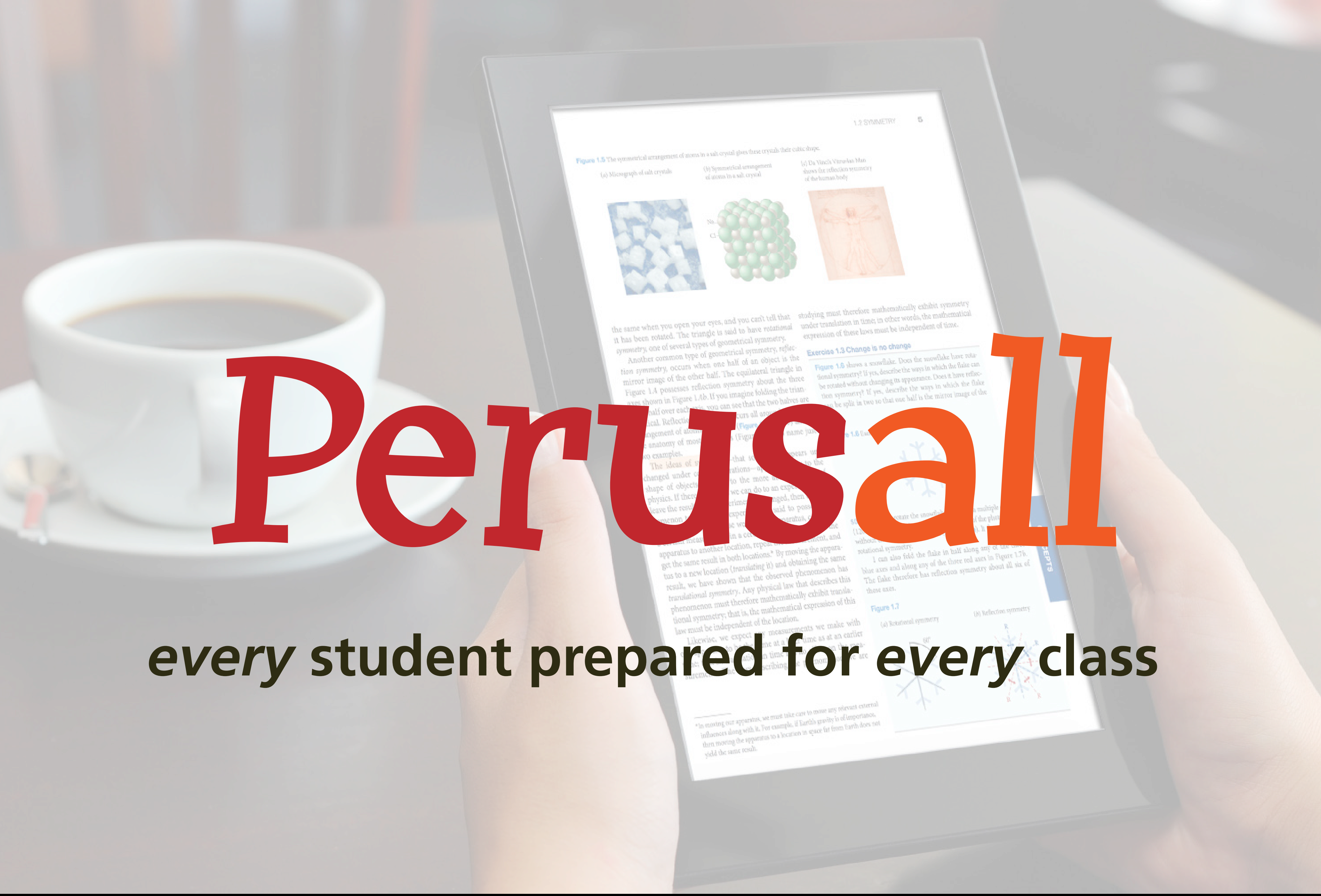
1 **design** 2 **approach**



Solution

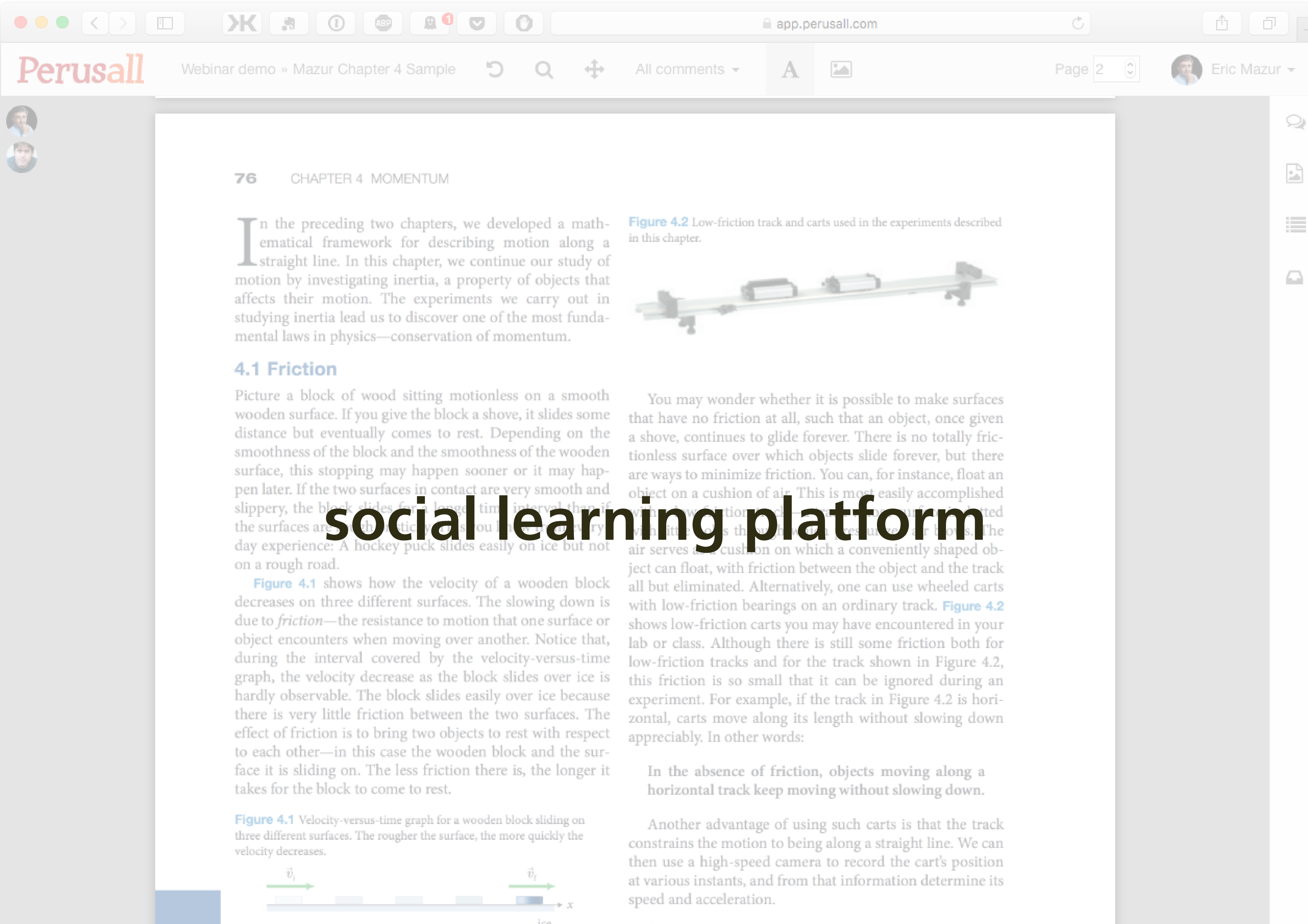
turn out-of-class component

also into a social interaction!



1 design

2 approach



social learning platform

1 design

2 approach

log in through social network

❶ design ❷ approach

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Perusall   Webinar demo » Mazur Chapter 4 Sample   All comments   Page 2   Eric Mazur

In the preceding two chapters, we developed a mathematical framework for describing motion along a straight line. In this chapter, we continue our study of motion by investigating inertia, a property of objects that affects their motion. The experiments we carry out in studying inertia lead us to discover one of the most fundamental laws in physics—conservation of momentum.

4.1 Friction

Picture a block of wood sitting motionless on a smooth wooden surface. If you give the block a shove, it slides some distance but eventually comes to rest. Depending on the smoothness of the block and the smoothness of the wooden surface, this stopping may happen sooner or it may happen later. If the two surfaces in contact are very smooth and slippery, the block slides for a longer time interval than if the surfaces are rough or sticky. This you know from everyday experience: A hockey puck slides easily on ice but not on a rough road.

Figure 4.1 shows how the velocity of a wooden block decreases on three different surfaces. The slowing down is due to *friction*—the resistance to motion that one surface or object encounters when moving over another. Notice that, during the interval covered by the velocity-versus-time graph, the velocity decrease as the block slides over ice is hardly observable. The block slides easily over ice because there is very little friction between the two surfaces. The effect of friction is to bring two objects to rest with respect to each other—in this case the wooden block and the surface it is sliding on. The less friction there is, the longer it takes for the block to come to rest.

Figure 4.1 Velocity-versus-time graph for a wooden block sliding on three different surfaces. The rougher the surface, the more quickly the velocity decreases.

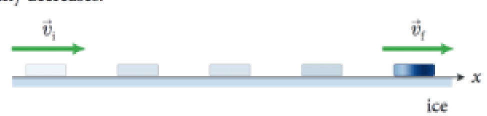
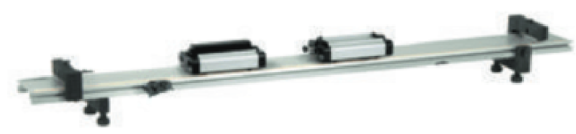


Figure 4.2 Low-friction track and carts used in the experiments described in this chapter.

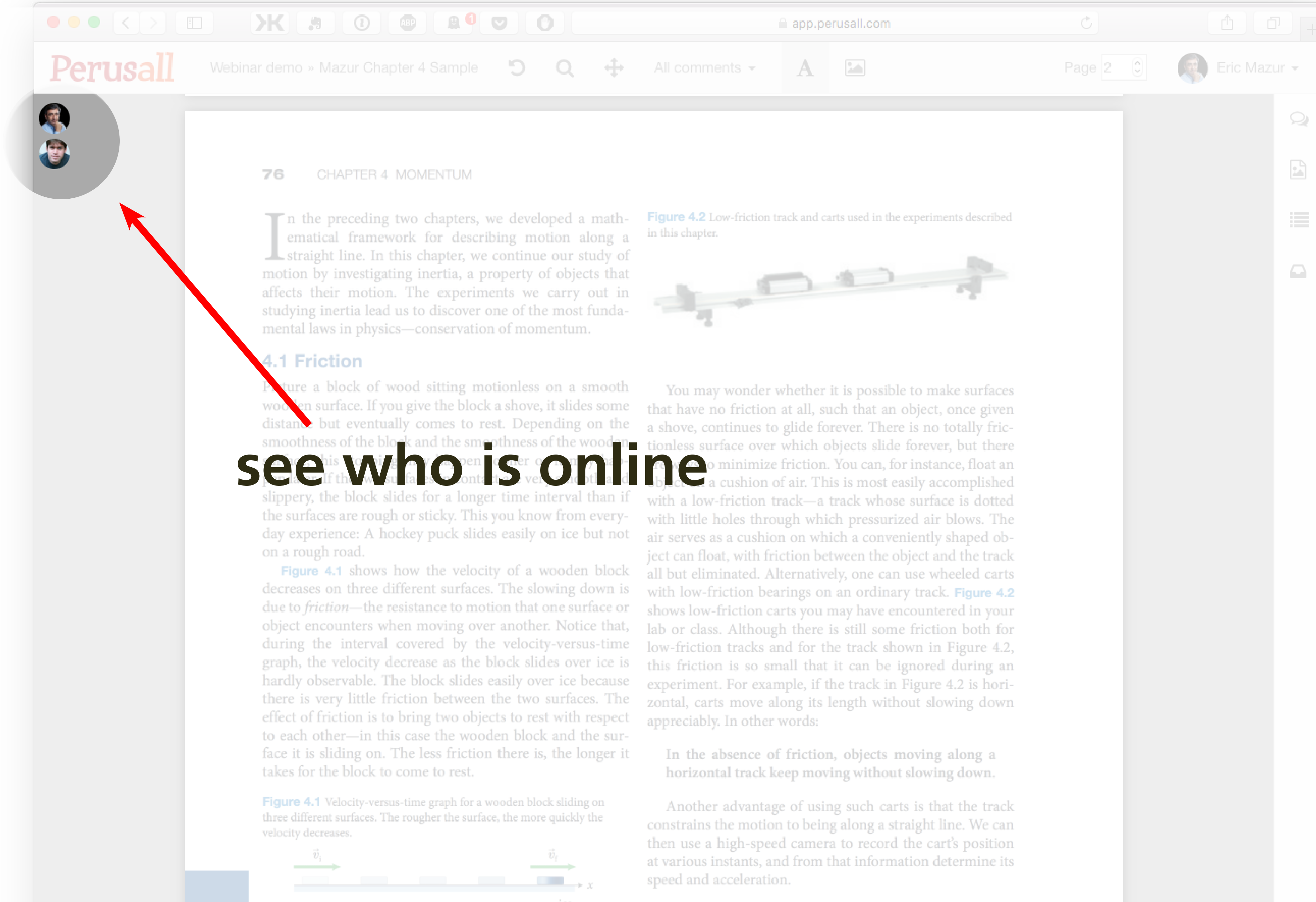


You may wonder whether it is possible to make surfaces that have no friction at all, such that an object, once given a shove, continues to glide forever. There is no totally frictionless surface over which objects slide forever, but there are ways to minimize friction. You can, for instance, float an object on a cushion of air. This is most easily accomplished with a low-friction track—a track whose surface is dotted with little holes through which pressurized air blows. The air serves as a cushion on which a conveniently shaped object can float, with friction between the object and the track all but eliminated. Alternatively, one can use wheeled carts with low-friction bearings on an ordinary track. Figure 4.2 shows low-friction carts you may have encountered in your lab or class. Although there is still some friction both for low-friction tracks and for the track shown in Figure 4.2, this friction is so small that it can be ignored during an experiment. For example, if the track in Figure 4.2 is horizontal, carts move along its length without slowing down appreciably. In other words:

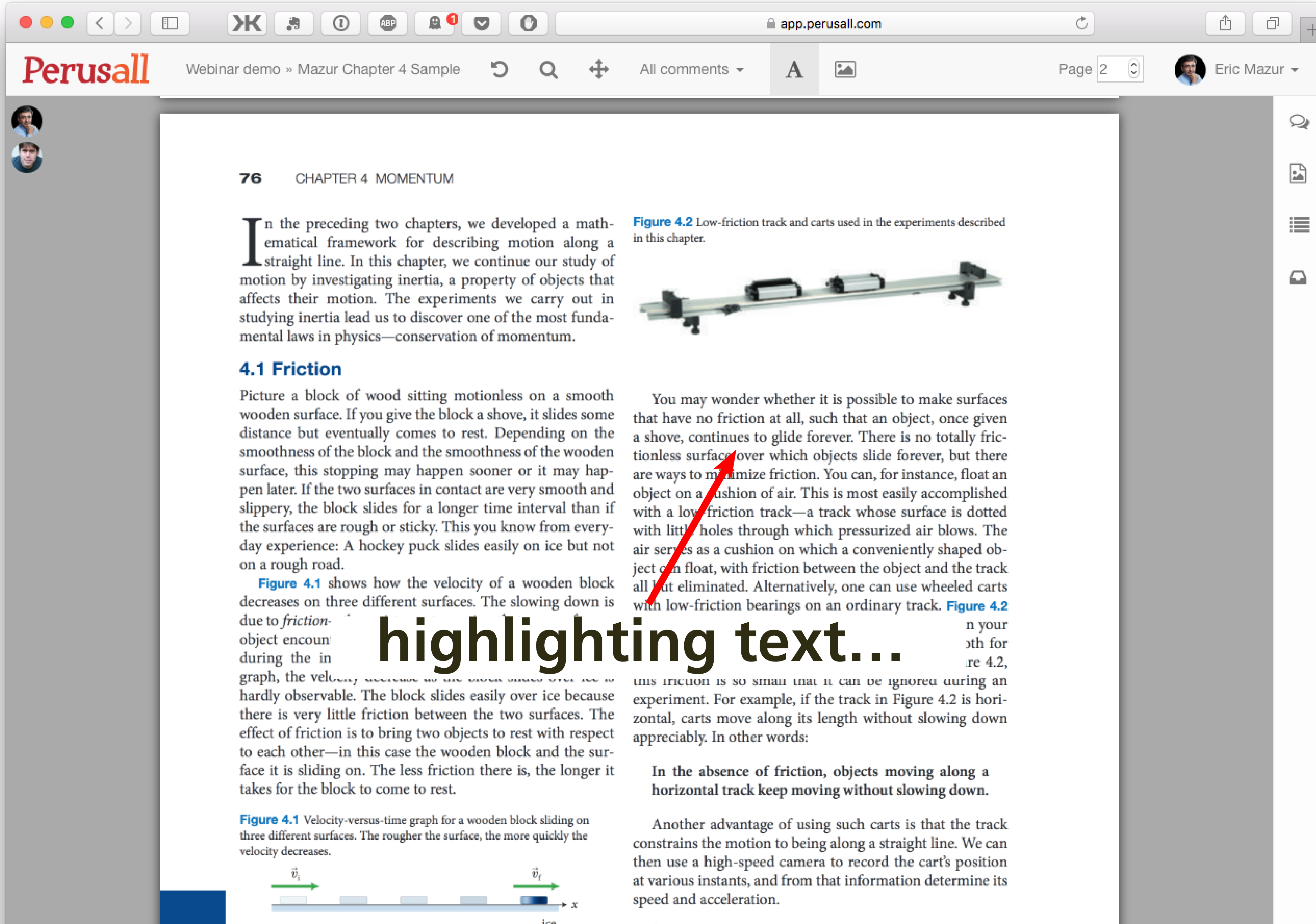
In the absence of friction, objects moving along a horizontal track keep moving without slowing down.

Another advantage of using such carts is that the track constrains the motion to being along a straight line. We can then use a high-speed camera to record the cart's position at various instants, and from that information determine its speed and acceleration.

1 design   **2 approach**



1 design 2 approach



76 CHAPTER 4 MOMENTUM

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Figure 4.1 Velocity-versus-time graph for a wooden block sliding on three different surfaces. The rougher the surface, the more quickly the velocity decreases.

$\vec{v}_i$ $\vec{v}_f$ x ice

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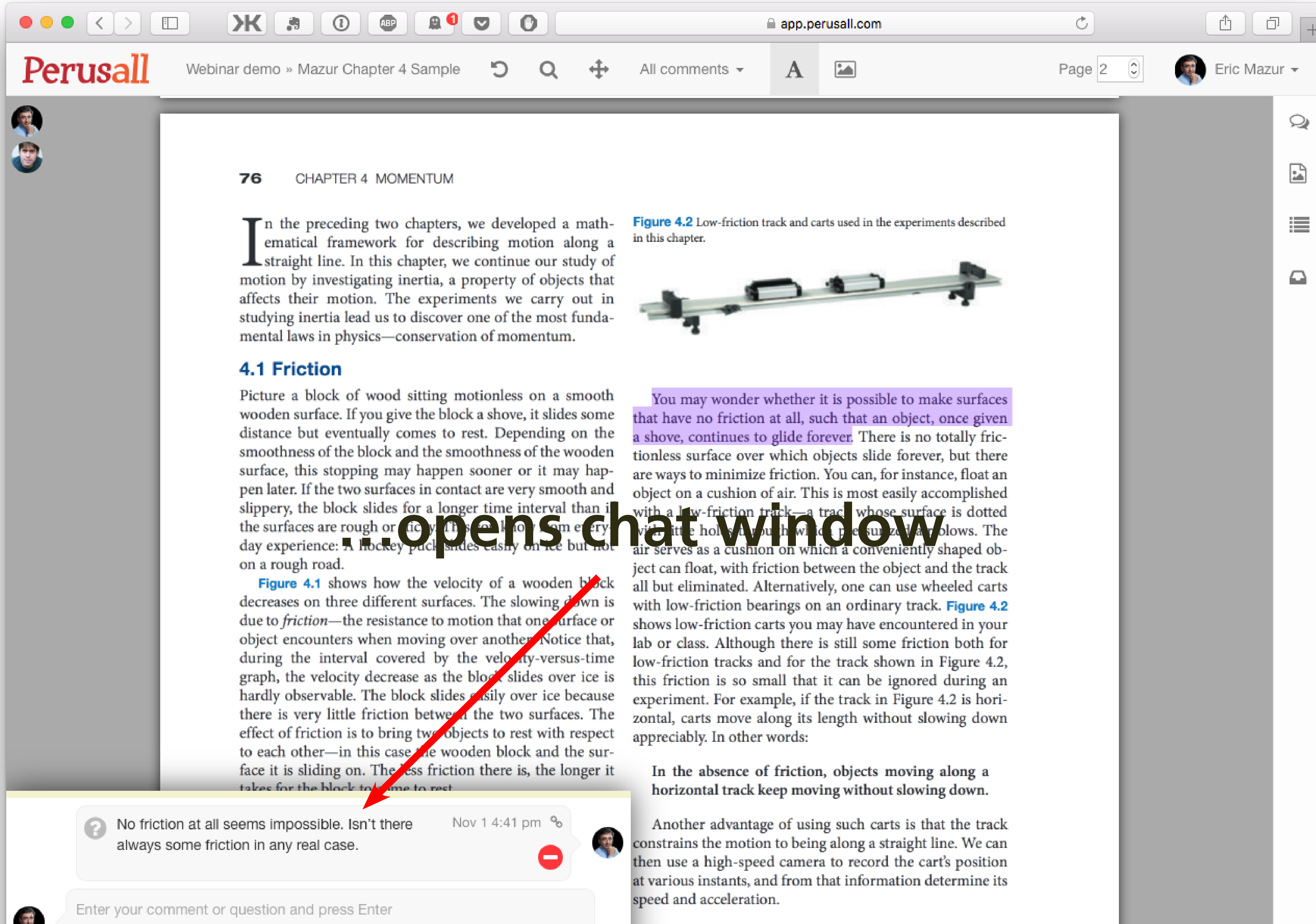
highlighting text…

1 design

2 approach



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1 design 2 approach

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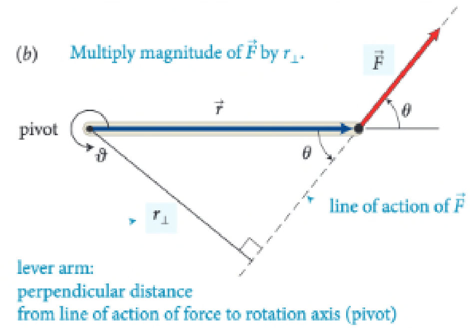
Perusall AP50 Fall 2015 » Chapter 12 Group 1's comments Page 284 Eric Mazur



action of the force and the axis of rotation. So, the torque caused by a force exerted on an object is the product of the magnitude of the force and its lever arm distance. It can be written equivalently as $rF_\perp$ and as $r_\perp F$.

Like other rotational quantities, torque carries a sign that depends on the choice of direction for increasing ϑ. In Figure 12.4, for example, the torque caused by $\vec{F}_1$ about the pivot tends to rotate the rod in the direction of increasing ϑ and so is positive; the torque caused by $\vec{F}_2$ is negative. The sum of the two torques about the pivot is then $r_1F_1 + (-r_2F_2)$. As we've seen, the two torques are equal in magnitude when the rod is balanced, and so the sum of the torques is zero. When the sum of the torques is not zero, the rod's rotational acceleration is nonzero, and so its rotational velocity and angular momentum change.

In the situations depicted in Figures 12.4 and 12.5 we used the pivot to calculate the lever arm distances. This is a natural choice because that is the point about which the object under consideration is free to rotate. However, torques also play a role for stationary objects that are suspended or supported at several different points and that are not free to rotate—for example, a plank or bridge supported at either end. To determine what reference point to use in such cases, complete the following exercise.

CONCEPTS

Exercise 12.1 Reference point

Consider again the rod in Figure 12.4. Calculate the sum of the torques about the left end of the rod.

SOLUTION I begin by making a sketch of the rod and the three

reference point

$\vec{F}_1$

The lever arm distances must now be determined relative to the left end of the rod. The lever arm distance of force $\vec{F}_1$ to this point is zero, and so the torque caused by that force about the left end of the rod is zero. If I choose counterclockwise as the positive direction of rotation, $\vec{F}_2$ causes a negative torque about the left end of the rod; the force $\vec{F}^c_{pr}$ exerted by the pivot causes a positive torque about the left end of the rod. The lever arm distance of $\vec{F}_2$ about the left end of the rod is $r_1 + r_2$; that of $\vec{F}^c_{pr}$ is r_1. Because the rod is at rest, the magnitude of the force exerted by the pivot is equal to the sum of the forces $\vec{F}_1$ and $\vec{F}_2$. Taking into account the signs of the torques, we find that the sum of the torques about the left end of the rod is $r_1(F_1 + F_2) - (r_1 + r_2)F_2 = r_1F_1 - r_2F_2$. This is the same result we obtained for the torques about the pivot, and so the sum of the torques about the left end is zero. ✔

Exercise 12.1 shows that the sum of the torques about the left end of the rod is zero, just like the sum of the torques about the pivot. You can repeat the calculation for the torques about the right end of the rod or any other point, and each time you will find that the sum of the torques is zero. The reason is that the rod is not rotating about any point, and so the sum of the torques must be zero about any point. In general we can say:

For a stationary object, the sum of the torques is zero.

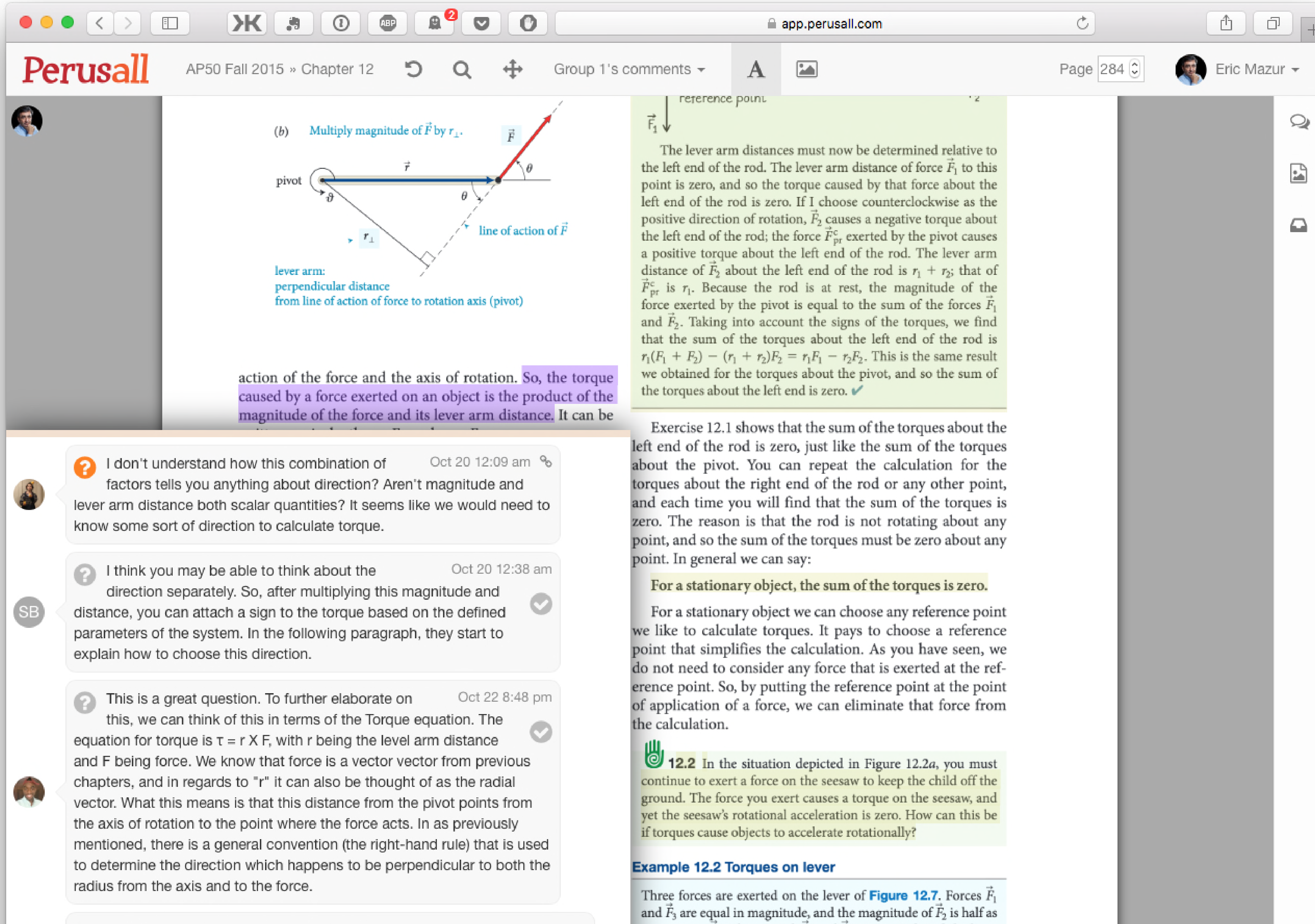
For a stationary object we can choose any reference point we like to calculate torques. It pays to choose a reference point that simplifies the calculation. As you have seen, we do not need to consider any force that is exerted at the reference point. So, by putting the reference point at the point of application of a force, we can eliminate that force from the calculation.

12.2 In the situation depicted in Figure 12.2*a*, you must continue to exert a force on the seesaw to keep the child off the ground. The force you exert causes a torque on the seesaw, and yet the seesaw's rotational acceleration is zero. How can this be if torques cause objects to accelerate rotationally?

Example 12.2 Torques on lever

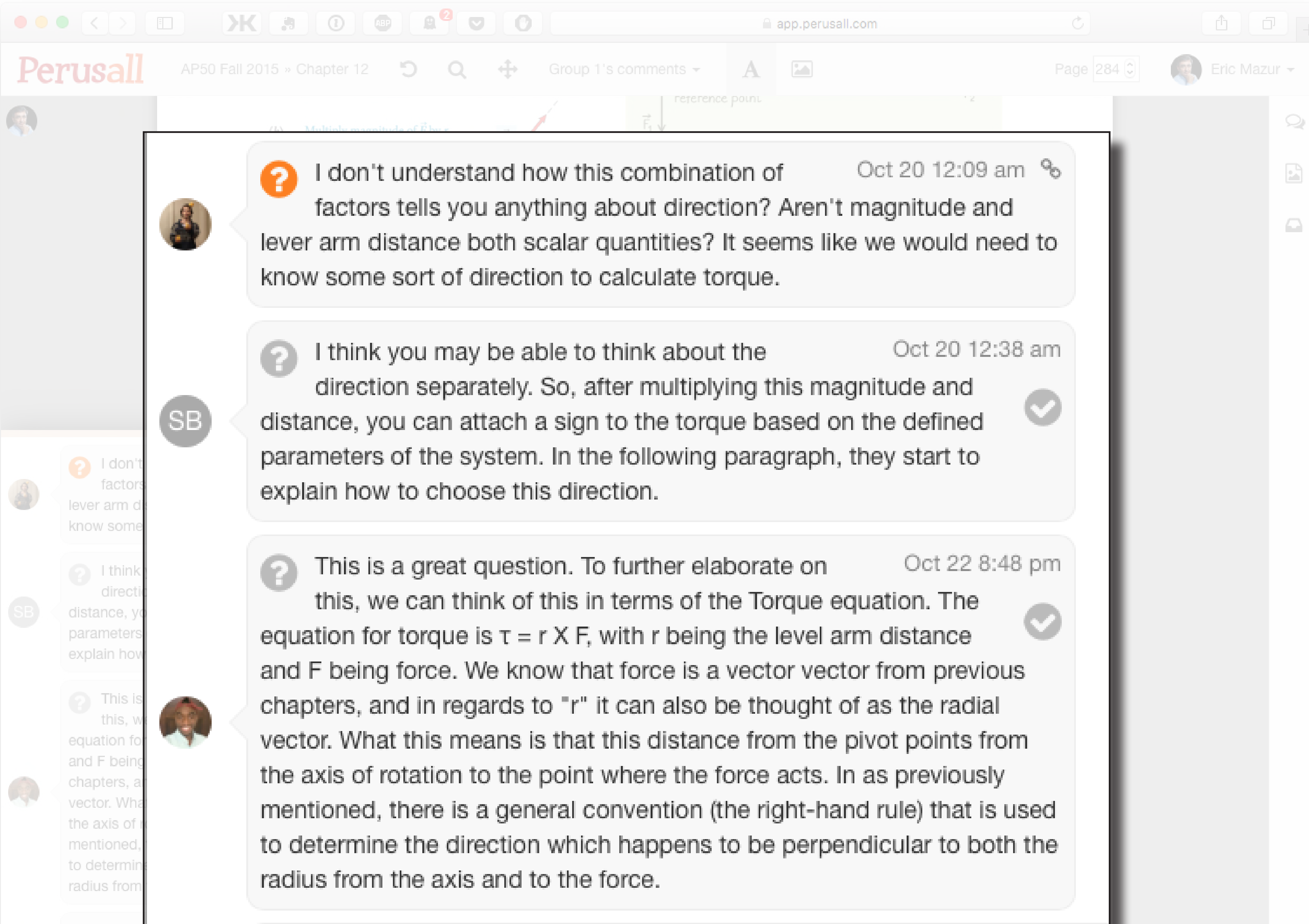
Three forces are exerted on the lever of Figure 12.7. Forces $\vec{F}_1$ and $\vec{F}_3$ are equal in magnitude, and the magnitude of $\vec{F}_2$ is half as great. Force $\vec{F}_1$ is horizontal, $\vec{F}_2$ and $\vec{F}_3$ are vertical, and the lever

1 design 2 approach



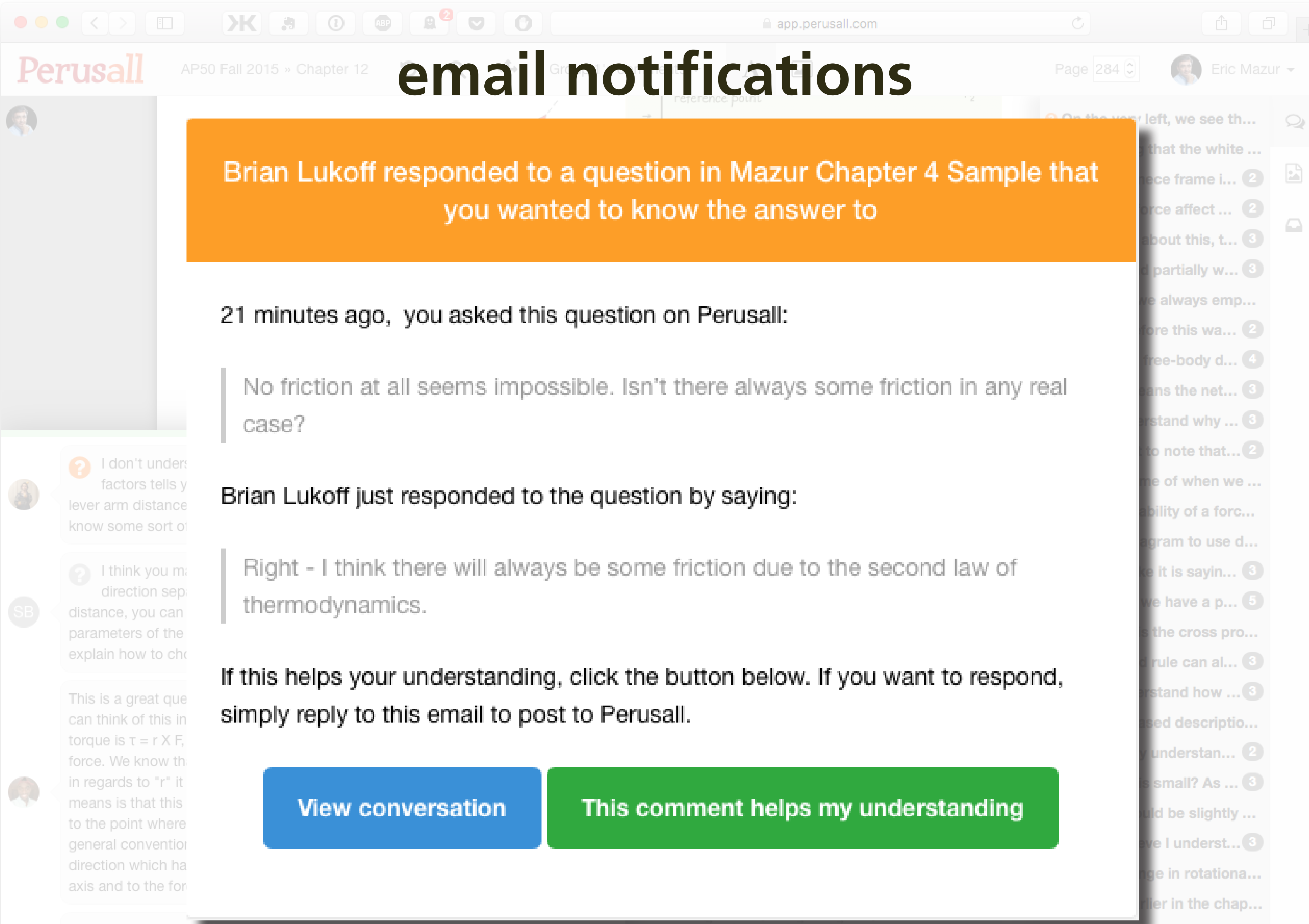
1 design

2 approach



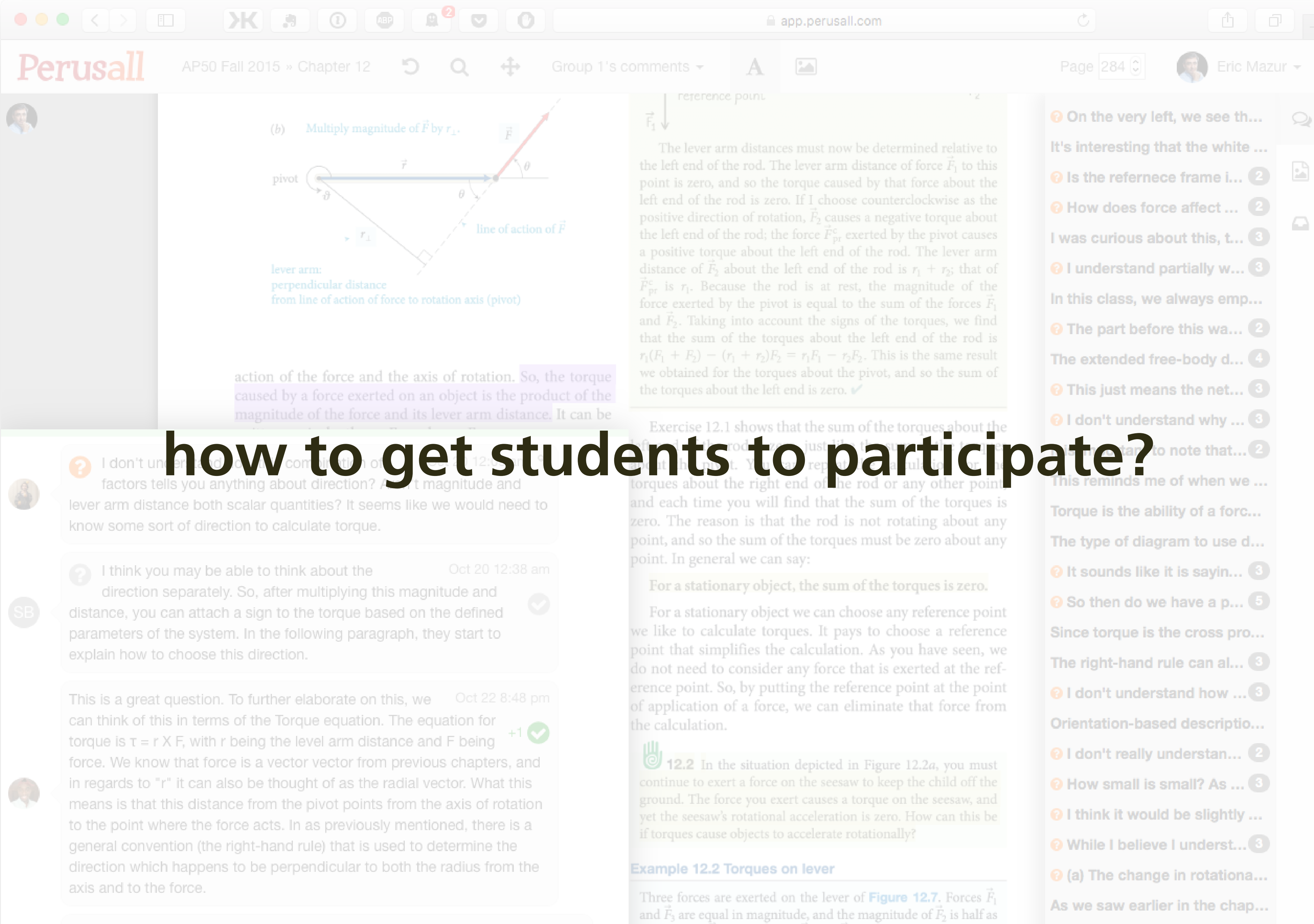
1 design 2 approach

email notifications



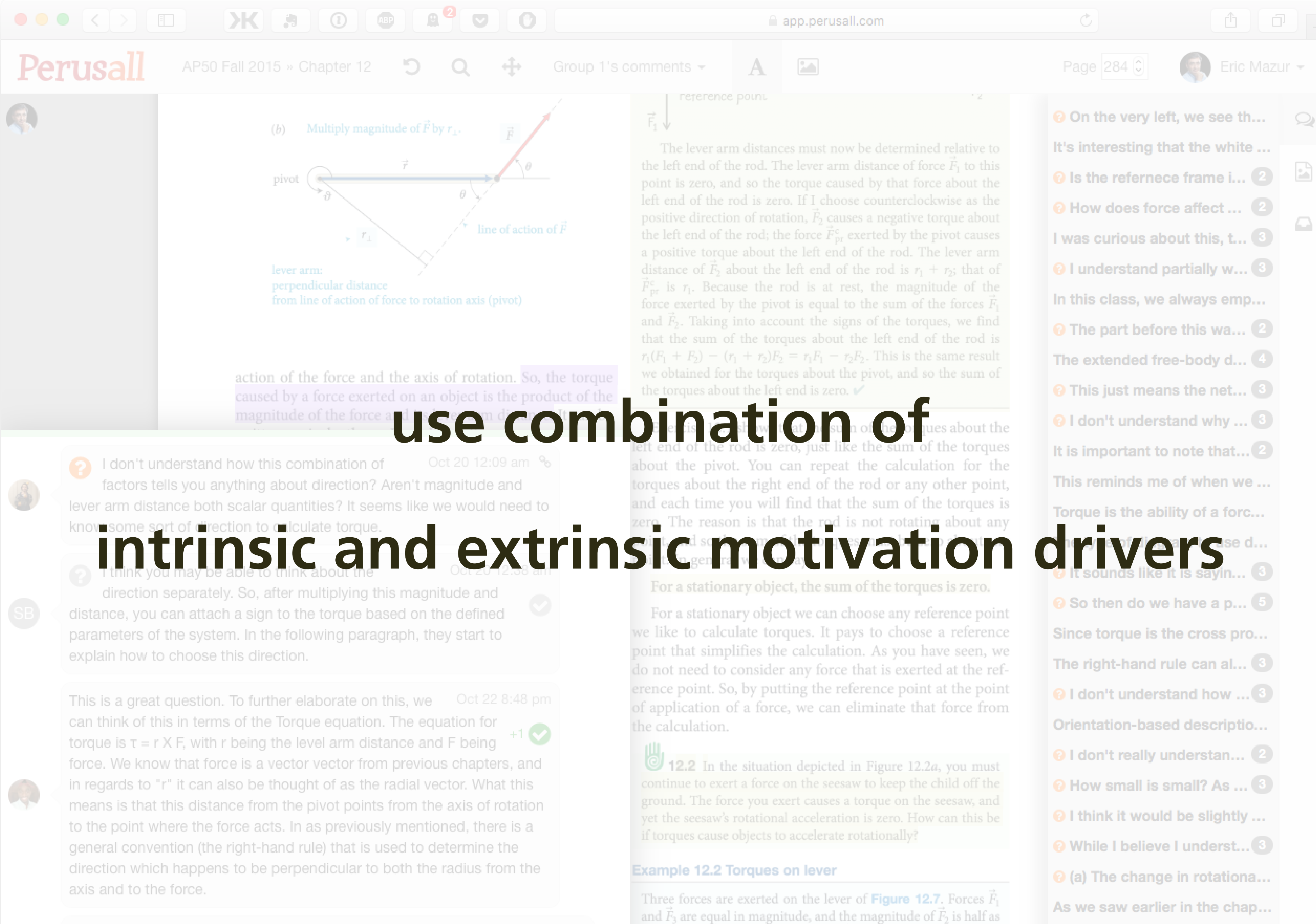
1 design

2 approach



how to get students to participate?

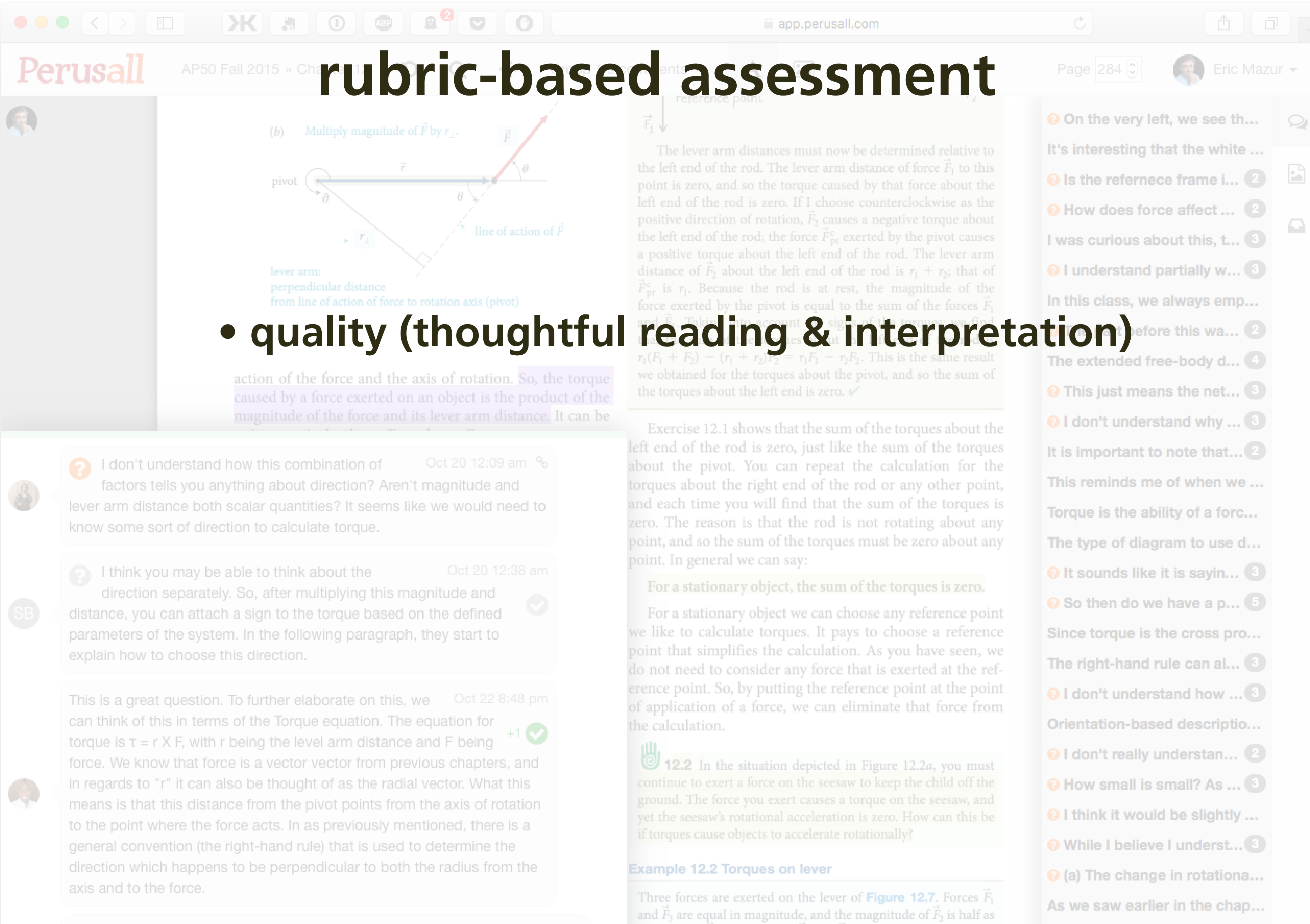
1. design
2. approach



use combination of intrinsic and extrinsic motivation drivers

❶ design ❷ approach

rubric-based assessment



- quality (thoughtful reading & interpretation)

❶ design ❷ approach

rubric-based assessment

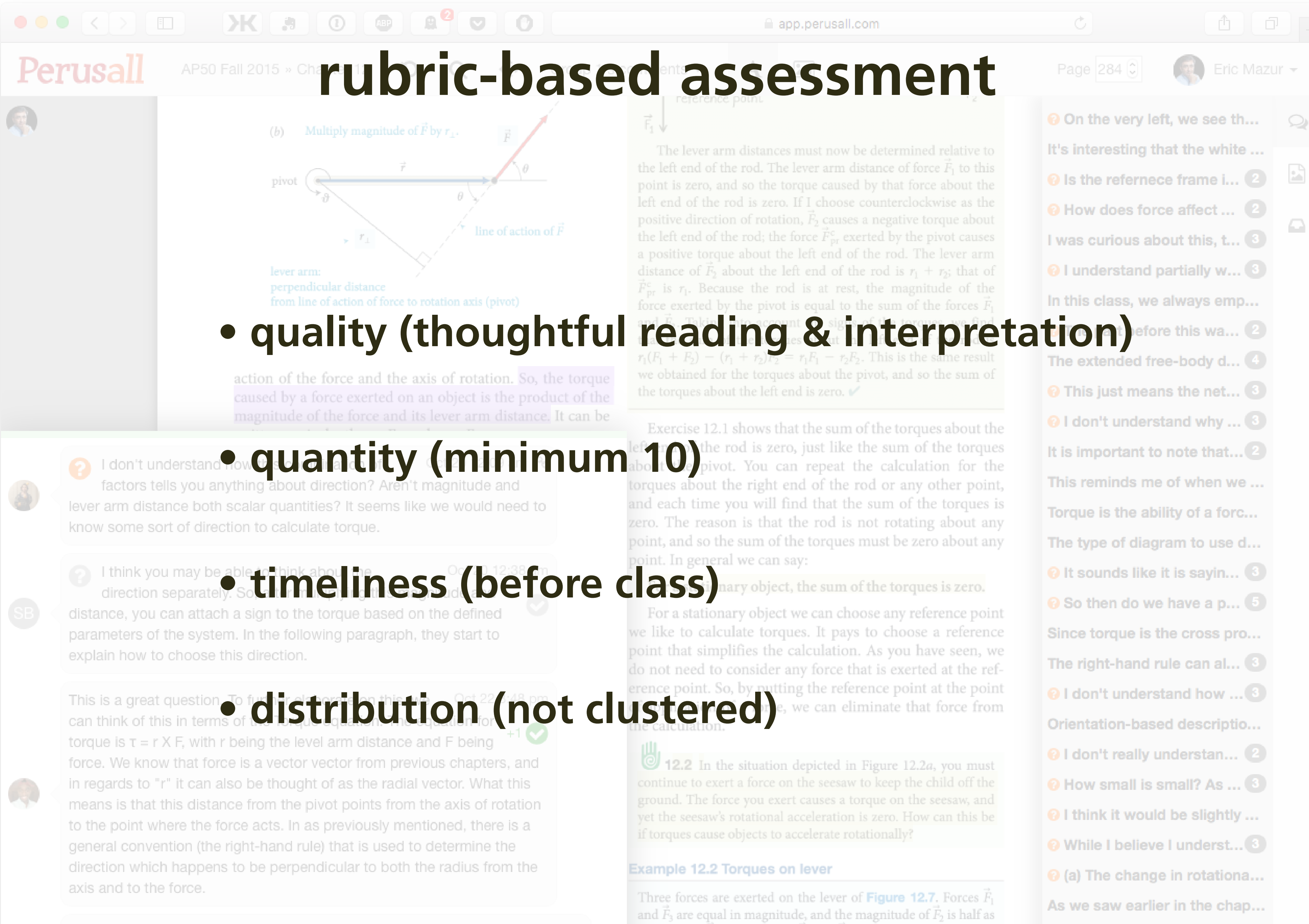
- quality (thoughtful reading & interpretation)
- quantity (minimum 10)

rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)

1 design **2 approach**

rubric-based assessment



- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)
- distribution (not clustered)

1 design 2 approach

rubric-based assessment

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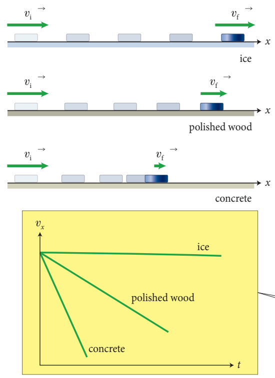
Picture a block of wood sitting motionless on a smooth wooden surface. If you give the block a shove, it slides some distance but eventually comes to rest. Depending on the smoothness of the block and the smoothness of the wooden surface, this stopping may happen sooner or it may happen later. If the two surfaces in contact are very smooth and slippery, the block slides for a longer time interval than if the surfaces are rough or sticky. This you know from everyday experience: A hockey puck slides easily on ice but not on a rough road.

Figure 4.1 shows how the velocity of a wooden block decreases on three different surfaces. The slowing down is due to *friction*—the resistance to motion that one surface or object encounters when moving over another. Notice that, during the interval covered by the velocity-versus-time graph, the velocity decrease as the block slides over ice is hardly observable. The block slides easily over ice because there is very little friction between the two surfaces. The effect of friction is to bring two objects to rest with respect to each other—in this case the wooden block and the surface it is sliding on. The less friction there is, the longer it takes for the block to come to rest.

Figure 4.1 Velocity-versus-time graph for a wooden block sliding on three different surfaces. The rougher the surface, the more quickly the velocity decreases.



CONCEPTS

Figure 4.2 Low-friction track and carts used in the experiments described in this chapter.

You may wonder whether it is possible to make surfaces that have no friction at all, such that an object, once given a shove, continues to glide forever. There is no totally frictionless surface over which objects slide forever, but there are ways to minimize friction. You can, for instance, float an object on a cushion of air. This is most easily accomplished with a low-friction track—a track whose surface is dotted with little holes through which pressurized air blows. The air serves as a cushion on which a conveniently shaped object can float, with friction between the object and the track all but eliminated. Alternatively, one can use wheeled carts with low-friction bearings on an ordinary track. Figure 4.2 shows low-friction carts you may have encountered in your lab or class. Although there is still some friction both for low-friction tracks and for the track shown in Figure 4.2, this friction is so small that it can be ignored during an experiment. For example, if the track in Figure 4.2 is horizontal, carts move along its length without slowing down appreciably. In other words:

In the absence of friction, objects moving along a horizontal track keep moving without slowing down.

Another advantage of using such carts is that the track constrains the motion to being along a straight line. We can then use a high-speed camera to record the cart's position at various instants, and from that information determine its speed and acceleration.

4.1 (*a*) Are the accelerations of the motions shown in Figure 4.1 constant? (*b*) For which surface is the acceleration largest in magnitude?

4.2 Inertia

We can discover one of the most fundamental principles of physics by studying how the velocities of two low-friction carts change when the carts collide. Let's first see what happens with two identical carts. We call these *standard carts* because we'll use them as a standard against which to compare the motion of other carts. First we put one standard cart on the low-friction track and make sure it doesn't move. Next we place the second cart on the track some distance from the first one and give the second cart a shove toward the first. The two carts collide, and the collision alters the velocities of both.

ANNOTATION	EVALUATION	
Alan: I remember, in high school, being amazed at how quickly carts could travel on these tracks - air would blow up through these tiny holes evenly distributed along the length of the track and the cart would essentially float on the air and consequently - the cart would move very quickly with the slightest push.	No substance. Does not demonstrate any thoughtful interpretation of the text.	0
Bob: Although there is no way to create frictionless surfaces, I find it interesting that we consider experiments "in the absence of friction." In a way, this relates back to Chapter 1.5 where we talked about the importance of having too little or too much information in our representations. In some cases, the friction is so insignificant that we ignore it (simplifying our representation).	Annotation interprets the text and demonstrates understanding of concepts through analogy and synthesis of multiple concepts.	2
Claire: Does this only apply to solid surfaces? I feel as if a substance that floats on water either has negligible or very little friction.	Possibly insightful question but does not elaborate on thought process, nor demonstrate thoughtful reading of the text.	1
Alan: Why is this? I don't get it.	Question does not explicitly identify point of confusion nor demonstrates thoughtful reading or interpretation of the text.	0
David: believe this applies to almost every surface, although I'm not sure if water would count more as resistance than friction. Anyways, the best example I could think of would be a surf board. If people who were paddling in the same direction as the waves experienced no resistance, they would continually speed up, and eventually reach very high speeds. However, in reality if they were two stop paddling they'd slow down and only the waves would slowly push them to shore.	Response demonstrates a thoughtful explanation with a claim substantiated with a concrete example	2
Alan: Is it possible to have a surface, in real life, that inflicts NO friction at all?	Question exhibits superficial reading, but does not exhibit any interpretation of the textbook.	1
Erica: Doesn't air resistance factor into this at all? It seems that it is not enough for there to be only an absense of friction for something to keep moving without slowing down. What about some other opposing force - like air resistance? Or is air resistance just another example of friction?	Demonstrates thoughtful interpretation of the text by refuting a statement through a counter example.	2
Bob: The key word is "appreciably". In the absense of friction, the cart does not slow down appreciably but still would a little due to air resistance	Responds to the question by thoughtfully interpreting the text	2
Alan: a) yes b) concrete has the acceleration of greatest magnitude	Annotation not backed up by any reasoning or theoretical assumptions. No evidence of thoughtful reading of text.	0
Erica: I would think that they are not constant because if we think of the formula F=ma, the force of friction is different in every case so that would change the acceleration value (where mass would stay the same since it's assumed that th object is the same in each situation).	Response backed up with reasoning that demonstrates an interpretation of the text and applies understanding of concepts	2
Claire: As a theoretical question about inertia, if an object in motion will stay in motion, but is being affected by friction, will it slow down perpetually but remain in motion, or will it eventually stop completely due to the friction? Just curious.	Profound question that goes beyond the material covered in the textbook.	2
Alan: With friction everything slows down to a half at one point or another. It is only if an outside force acts on the object if that object will maintain motion after the effects of inertia.	Demonstrates some thought but does not really address Claire's question	1
Claire: Standard carts: identical carts in mass, shape, etc. I like this notion of standard carts, it provides a good baseline to compare other motion and to understand the concepts before building on it.	No substance. Does not demonstrate any thoughtful reading.	0
Alan: Great visual representation of friction! It is interesting how this compares the velocity of things on different surfaces	No substance. Does not demonstrate any thoughtful reading.	0
Bob: The rougher the surface, the more friction between the surface and the wooden block, and thus acceleration will be greater.	Interprets the graph and applies understanding of both the concept of friction, how a v-t graph correponds to acceleration and the relationship between the force of friction and acceleration	2

1 design

2 approach

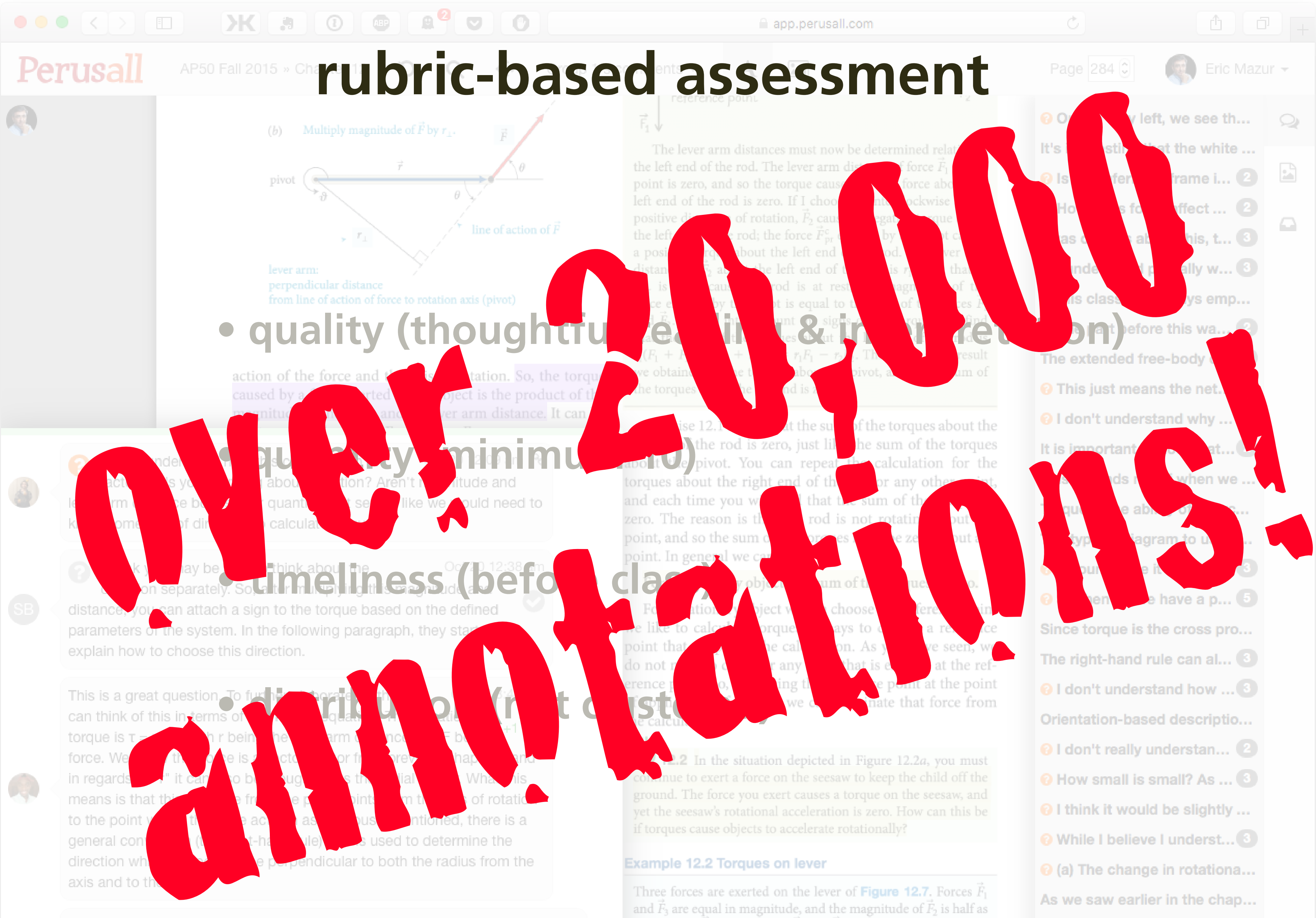
rubric-based assessment

ANNOTATION	EVALUATION
Alan: I remember, in high school, being amazed at how quickly carts could travel on these tracks - air would blow up through these tiny holes evenly distributed along the length of the track and the cart would essentially float on the air and consequently - the cart would move very quickly with the slightest push.	No substance. Does not demonstrate any thoughtful interpretation of the text. **0**
Bob: Although there is no way to create frictionless surfaces, I find it interesting that we consider experiments "in the absence of friction." In a way, this relates back to Chapter 1.5 where we talked about the importance of having too little or too much information in our representations. In some cases, the friction is so insignificant that we ignore it (simplifying our representation).	Annotation interprets the text and demonstrates understanding of concepts through analogy and synthesis of multiple concepts. **2**
Claire: Does this only apply to solid surfaces? I feel as if a substance that floats on water either has negligible or very little friction.	Possibly insightful question but does not elaborate on thought process, nor demonstrate thoughtful reading of the text. **1**
Alan: Why is this? I don't get it.	Question does not explicitly identify point of confusion nor demonstrates thoughtful reading or interpretation of the text. **0**
David: believe this applies to almost every surface, although I'm not sure if water would count more as resistance than friction. Anyways, the best example I could think of would be a surf board. If people who were paddling in the same direction as the waves experienced no resistance, they would continually speed up, and eventually reach very high speeds. However, in reality if they were two stop paddling they'd slow down and only the waves would slowly push them to shore.	Response demonstrates a thoughtful explanation with a claim substantiated with a concrete example **2**

1 design

2 approach

rubric-based assessment



- quality (thoughtful reading & interpretation)
- quantity (minimum 7)
- timeliness (before class)
- distribution (not clustered)

over 20,000 annotations!

❶ design ❷ approach

rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)
- distribution (not clustered)

how do you process all of that??

1 design 2 approach

rubric-based assessment

- quality (thoughtful interpretation)
- quantity (minimum 10)

how do you process all of that??

- timeliness (before class)
- distribution (not clustered)

fully automated assessment

1 design

2 approach

fully automated assessment

- specialized machine learning algorithm
- assesses intellectual content
- exceeds intercoder reliability

1 design   2 approach

gradebook

Gradebook

Click on a grade to see details about the student's assignment.

Copy to clipboard | Download

Search:

Student Name	Student ID	Chapter 1	Chapter 2	Ch
[illegible]		3	2	
[illegible]		3	3	
[illegible]		3	3	
[illegible]				
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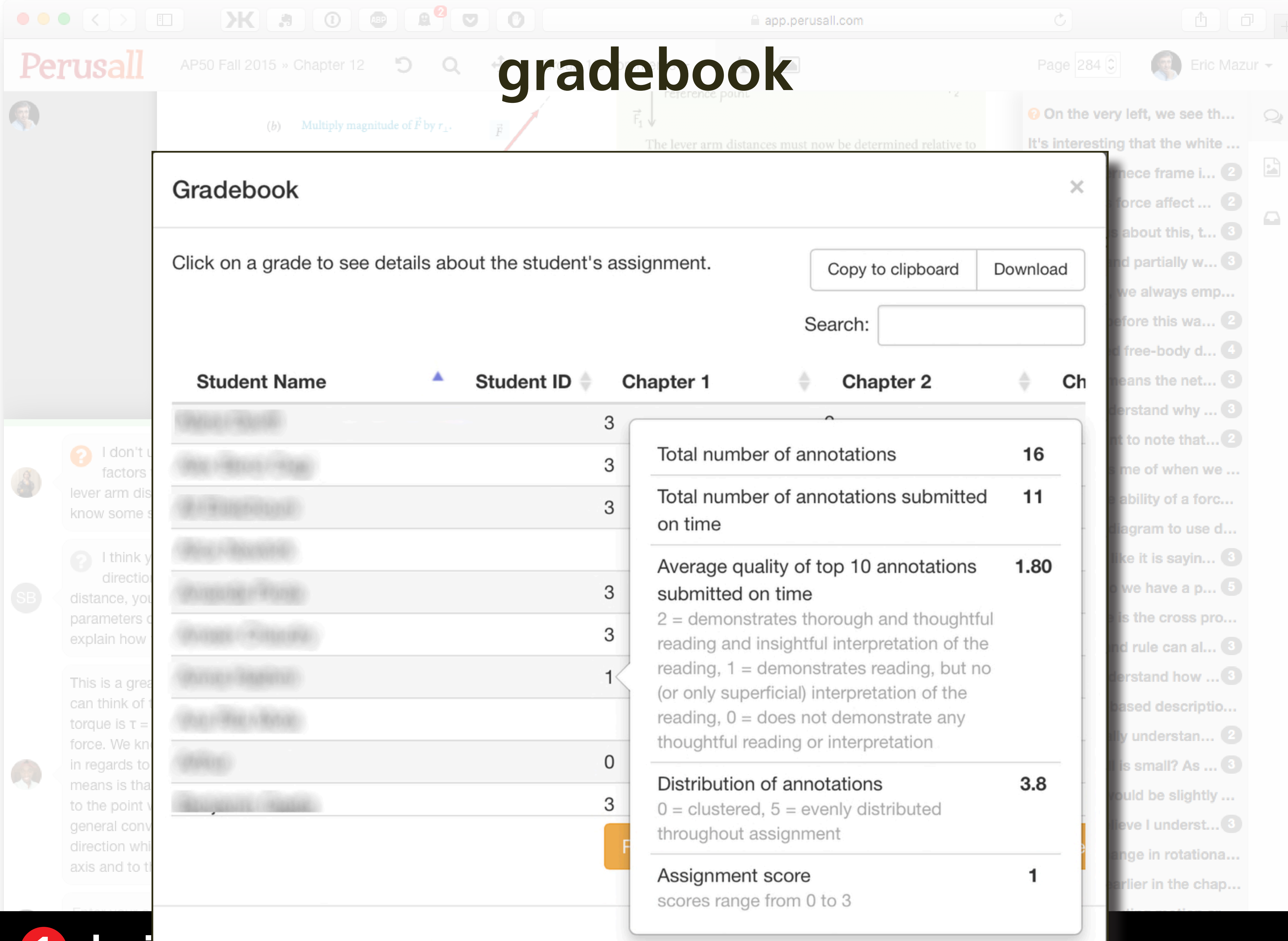
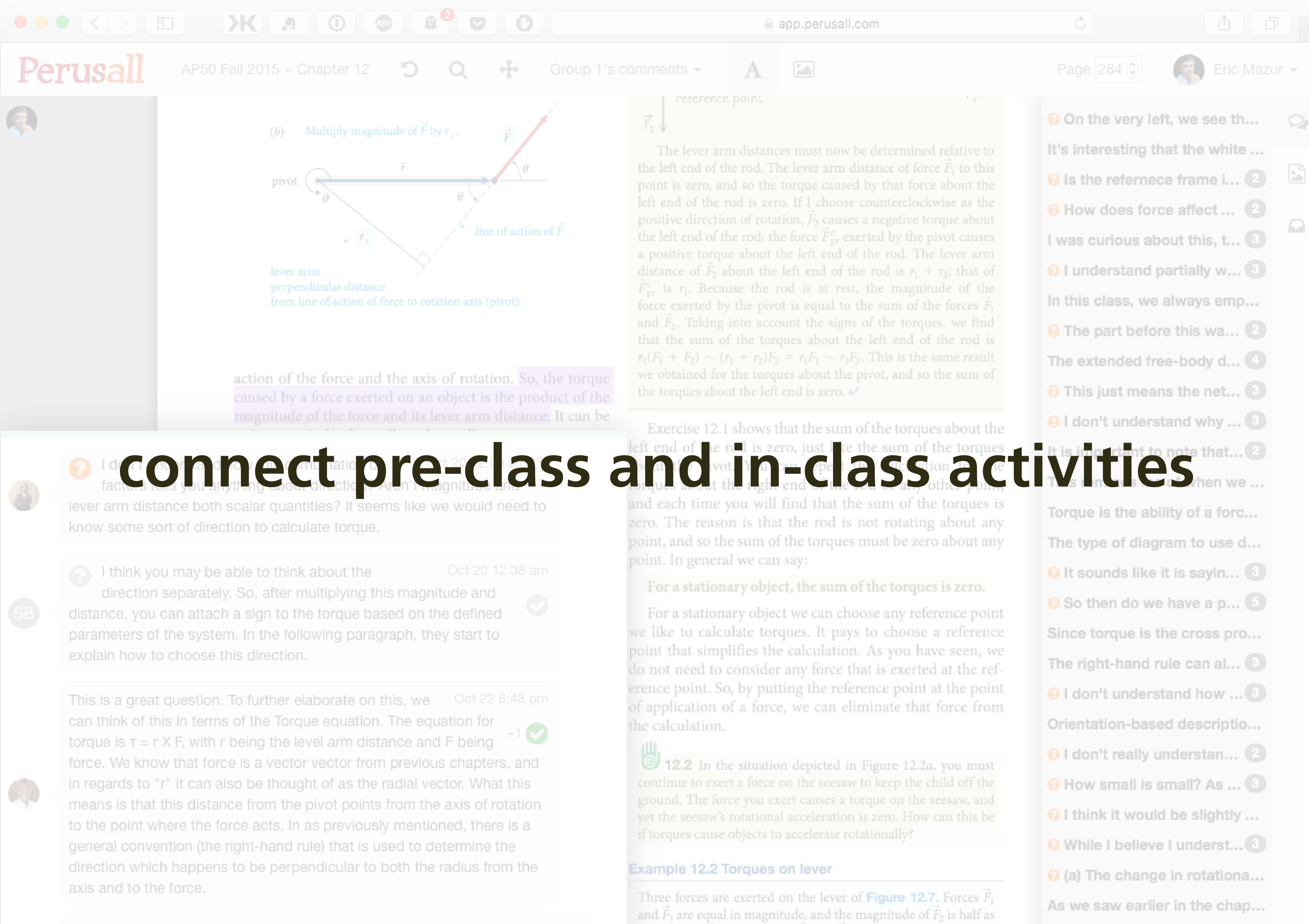
1 design

2 approach

gradebook



1 design 2 approach



connect pre-class and in-class activities

1 design

2 approach

confusion report

Confusion report for Chapter 24

×

right hand rule (11 questions)

JB — Can someone in simpler terms explain the right- hand rule? +1

WJ — Is there another way, besides the right hand rule, to find the direction of the magnetic field with a current?

SB — Using the right hand rule, I believe the answer is D. Is that correct?

Show more...

direction magnetic field (8 questions)

CP — Why is it that the magnet field points away from the north pole and towards the south pole? When on the previous page it stated that the direction of the magnetic field is the direction that the north pole of a compass needle points. +2

AB — How can you determine which direction the magnetic field will point towards? +1

KH — So whichever way the north pole faces is the direction of the magnetic field but that doesn't always mean its pointing true north? +1

Show more...

earth magnetic field (6 questions)

CP — Does that mean that the compass will be distracted from the Earth's magnetic field and use the magnetic field that the current of the wire gives off?

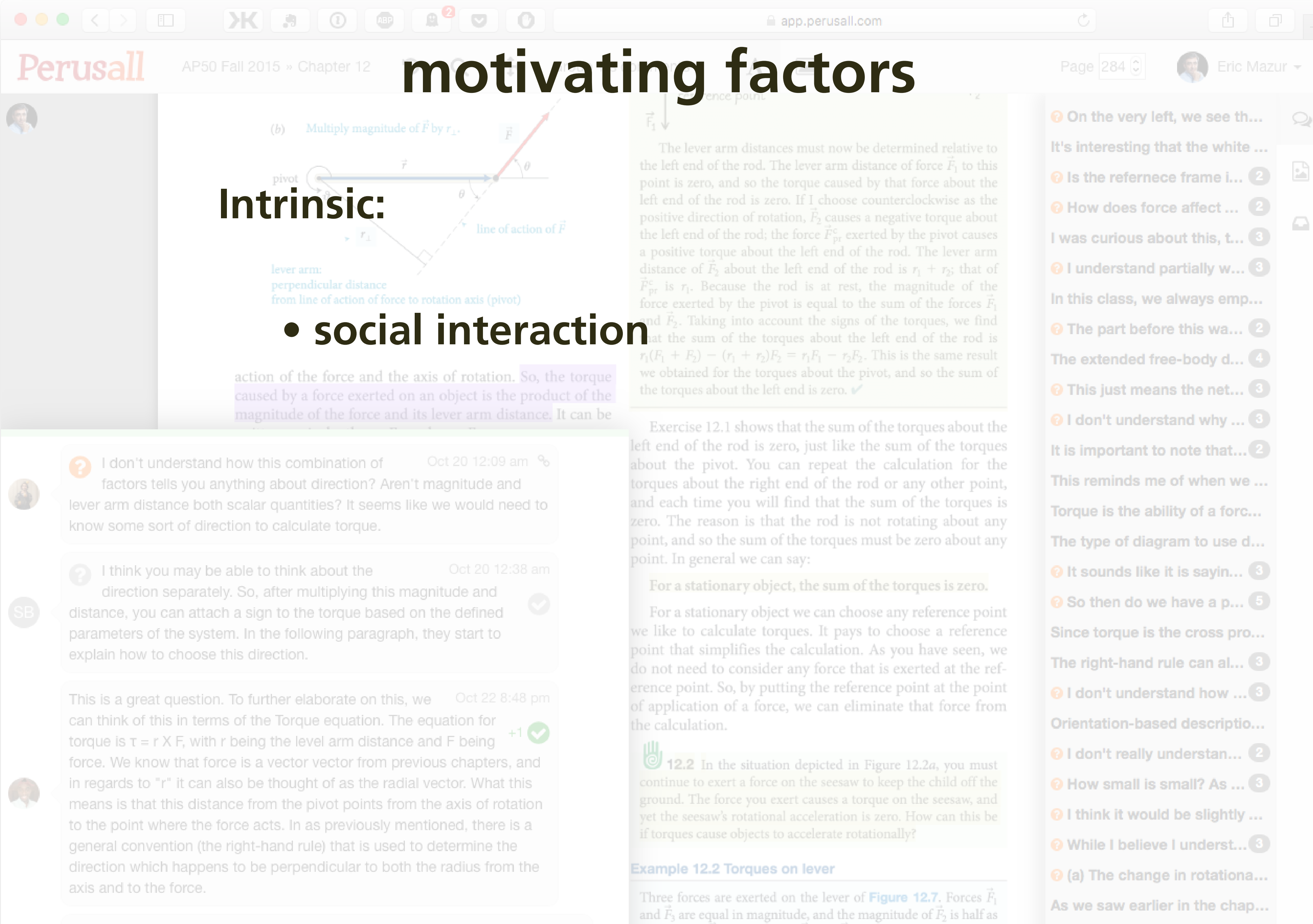
AK — Can someone explain why this type of bacteria knows what direction the earth's magnetic fields are facing?

J — Does the circular loop of current have any similarities with the look of the earths magnetic field? They kind of look similar to me.

Show more...

1 design

motivating factors



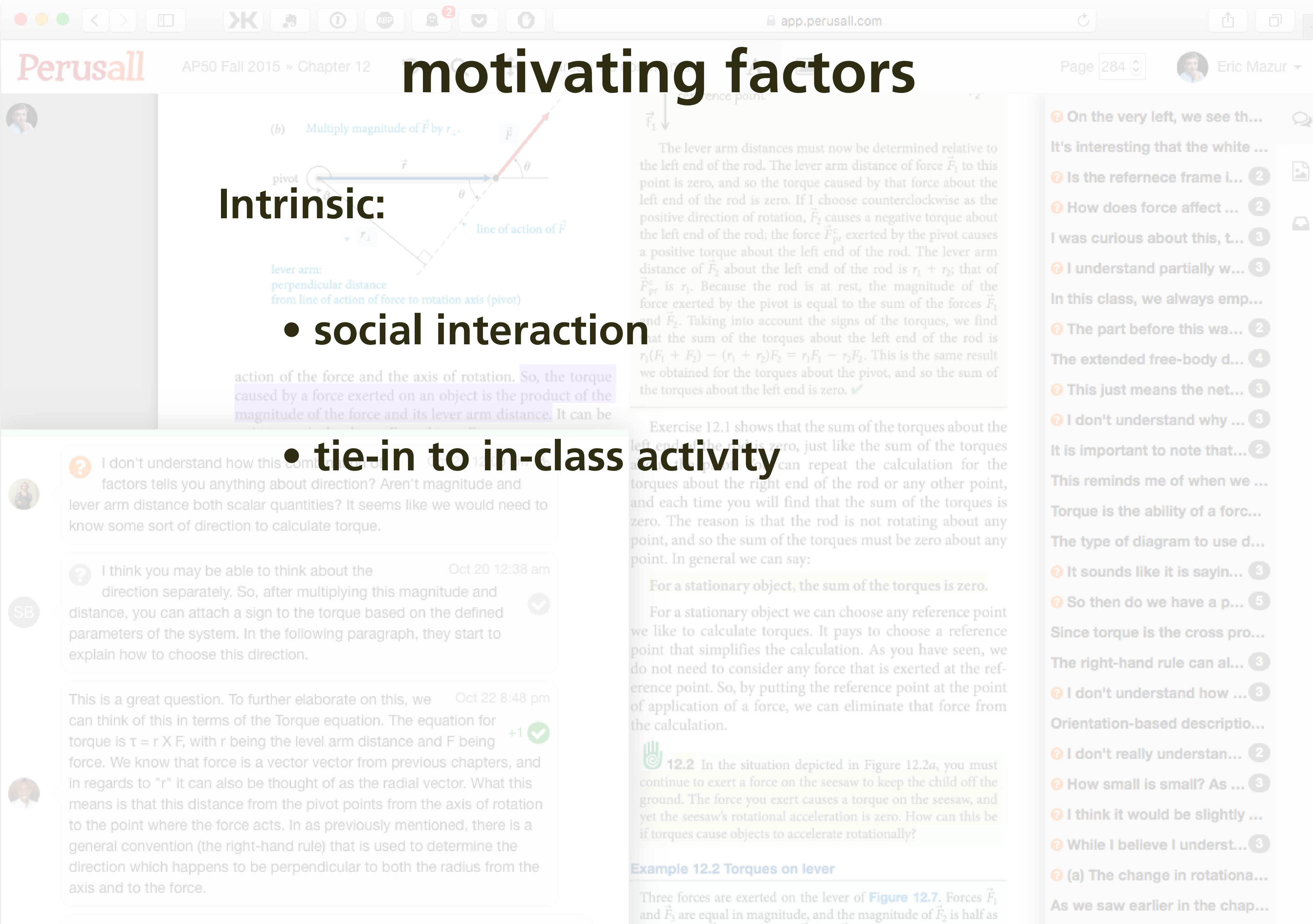
Intrinsic:

- social interaction

1 design

2 approach

motivating factors



Intrinsic:

- social interaction
- tie-in to in-class activity

1 design

2 approach

motivating factors

Intrinsic:

- social interaction
- tie-in to in-class activity

Extrinsic:

- assessment (fully automated)

motivating factors

"I think the Perusall app and annotation system is way better than just reading a text-book normally… I've been reading for almost four hours now and haven't gotten bored"

Harvard student

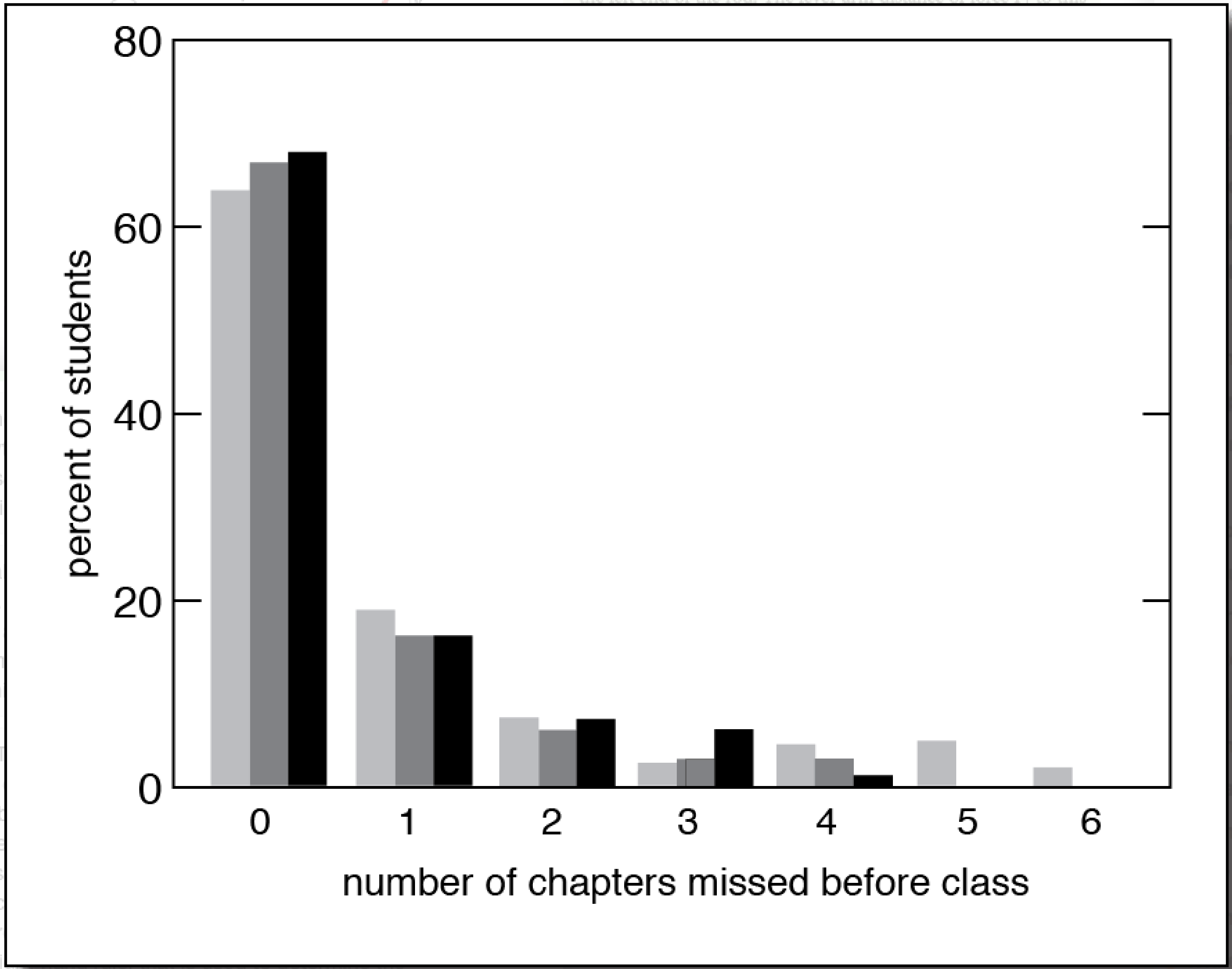
motivating factors

"It makes the book fun to read... All the other students on my floor are disappointed their Prof isn't using Perusall because they don't read the book."

Ohio State student

1 design 2 approach

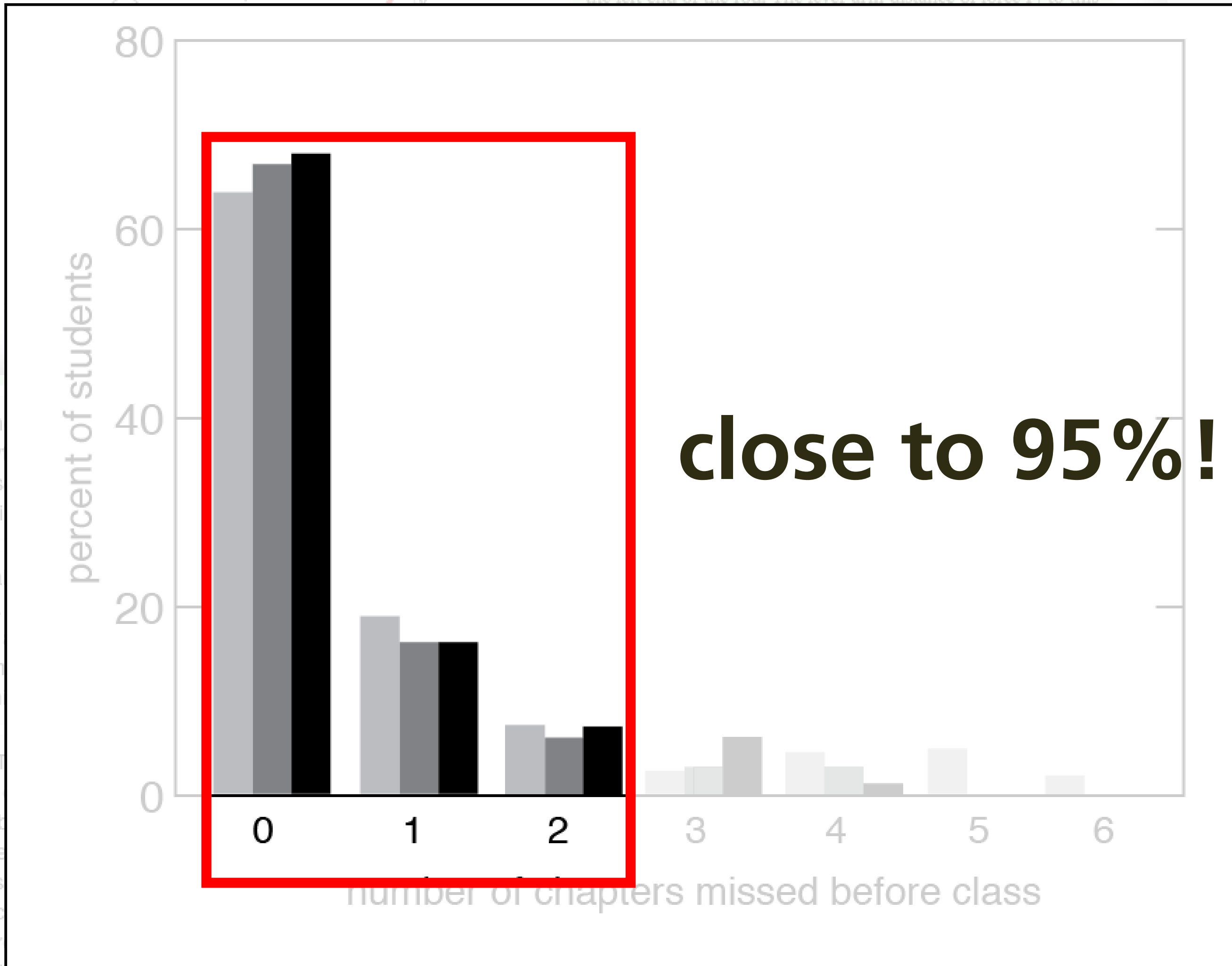
participation



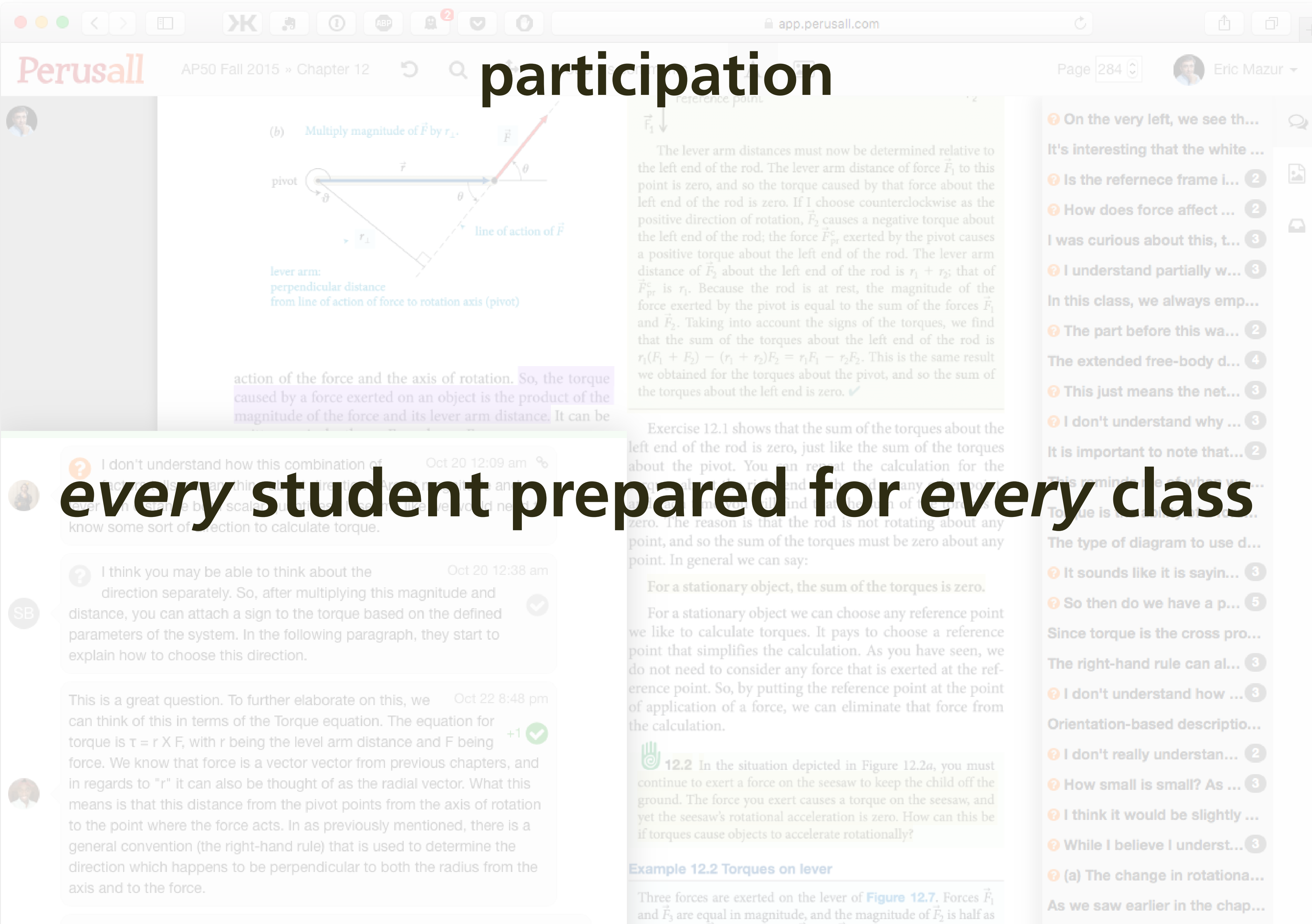
1 design

2 approach

participation



1 design   **2 approach**



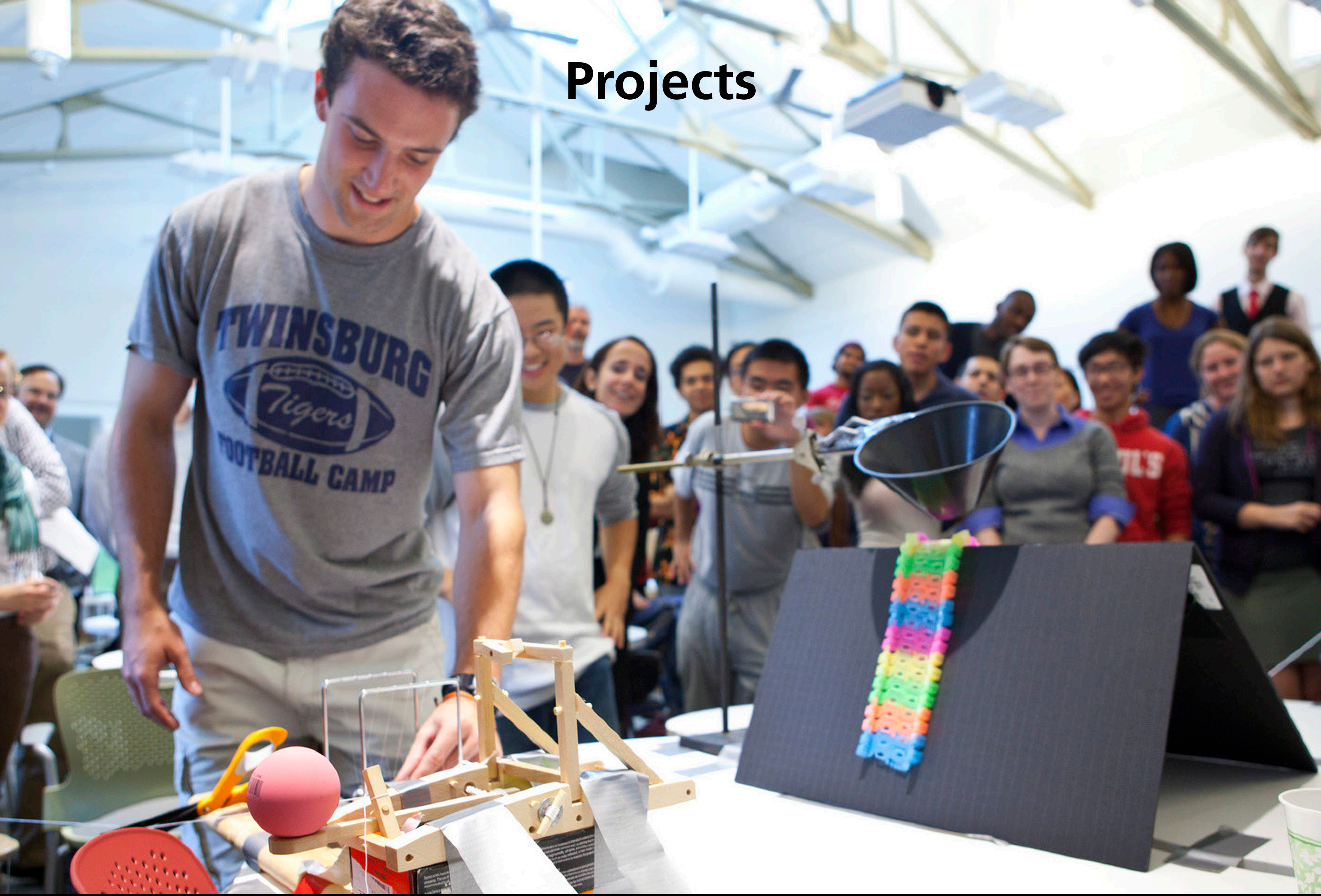
participation

every student prepared for *every* class

1 design

2 approach

Projects



1 design

2 approach

Projects

- 1 project/month (6 over 2 semesters)
- new team formation for each project
- projects not prescriptive, but open-ended
- 3 types of project “fairs”
- external evaluators

Projects

Rule-based team formation using GroupEng

www.GroupEng.org

1 design

2 approach

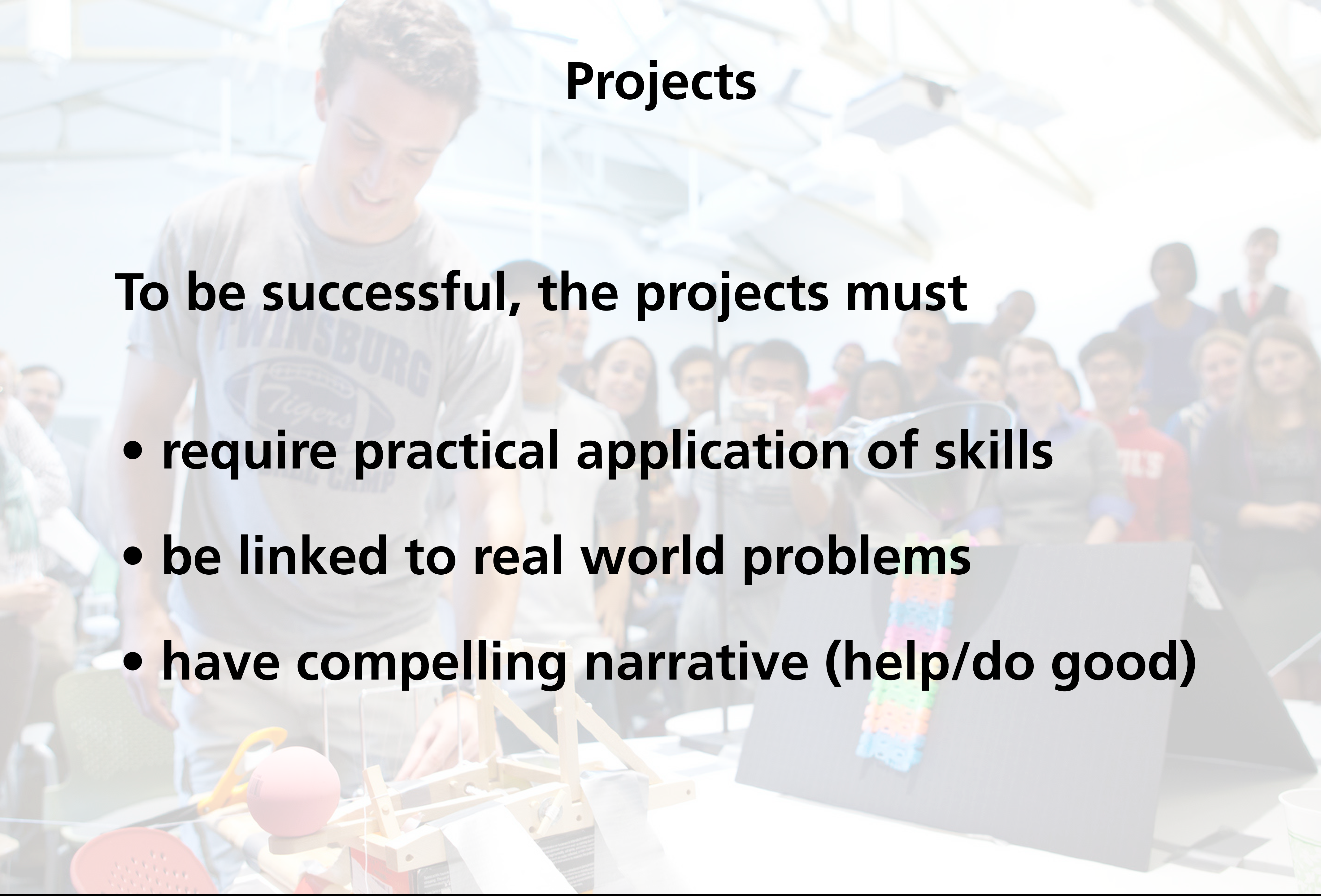
Projects

Rule-based team formation using GroupEng

- gender
- year
- self-efficacy & learning attitude
- class performance
- exlude previous team mates

www.GroupEng.org

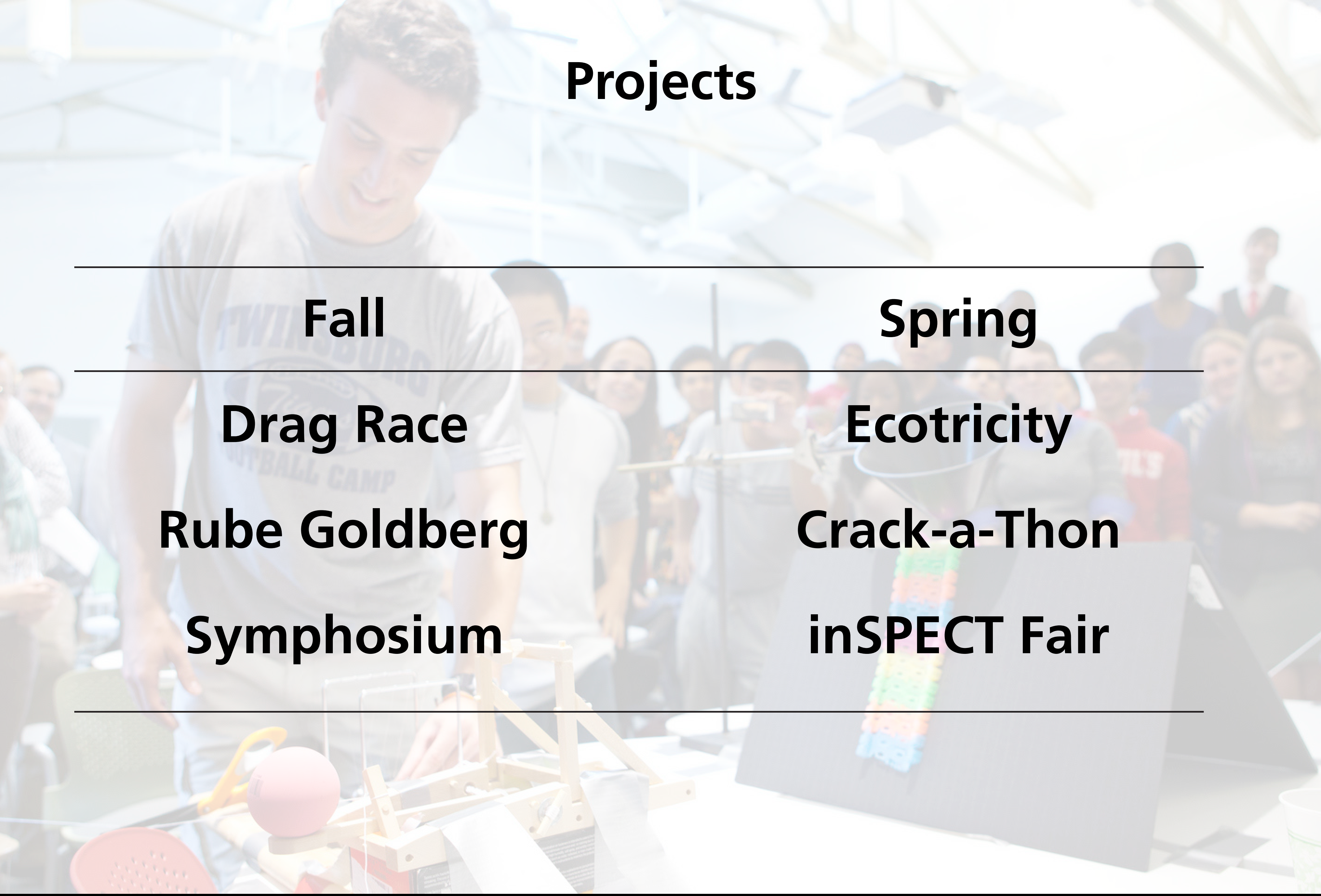
1 design   2 approach



Projects

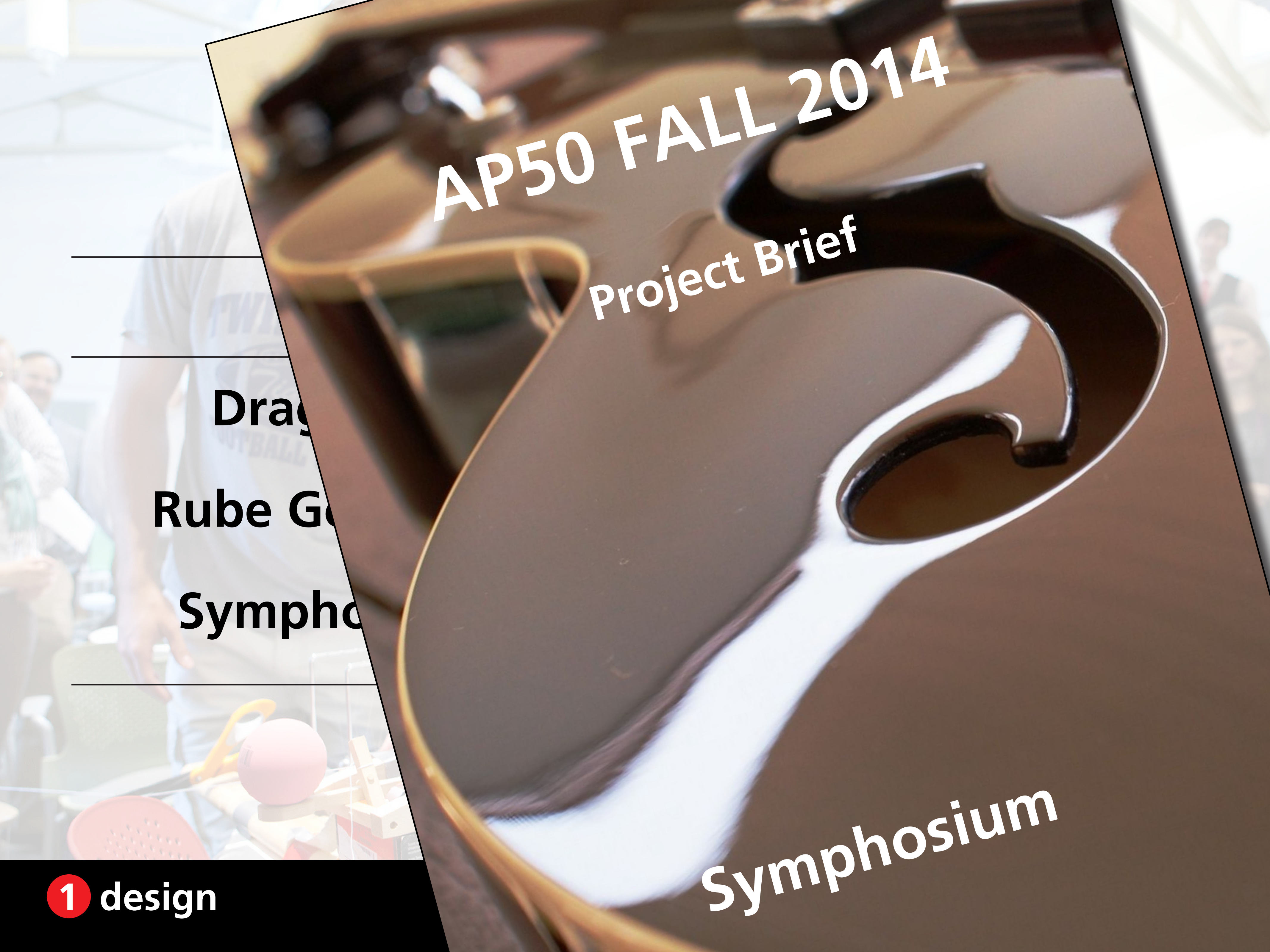
To be successful, the projects must

- **require practical application of skills**
- **be linked to real world problems**
- **have compelling narrative (help/do good)**



Projects

Fall	Spring
Drag Race	Ecotricity
Rube Goldberg	Crack-a-Thon
Symphosium	inSPECT Fair



AP50 FALL 2014
Project Brief
Symphosium
Drag
Rube Go
Sympho
1 design

1 design

2 approach

Projects

❶ design ❷ approach

Projects

Build a beautifully sounding instrument from recycled parts

Projects

Build a beautifully sounding instrument from recycled parts

- musical range
- *Q*-factor
- harmonic spectrum
- sound level
- tuning stability

Projects

Milestones:

- team contract
- proposal
- fair
- report
- team, peer, and self assessment

Projects

Milestones:

- team contract (at beginning)
- proposal
- fair
- report
- team, peer, and self assessment

Projects

Milestones:

- team contract (at beginning)
- proposal (+1 week)
- fair
- report
- team, peer, and self assessment

Projects

Milestones:

- team contract (at beginning)
- proposal (+1 week)
- fair (+3 weeks)
- report
- team, peer, and self assessment

Projects

Milestones:

- team contract (at beginning)
- proposal (+1 week)
- fair (+3 weeks)
- report (+1 week +3 days for revision)
- team, peer, and self assessment

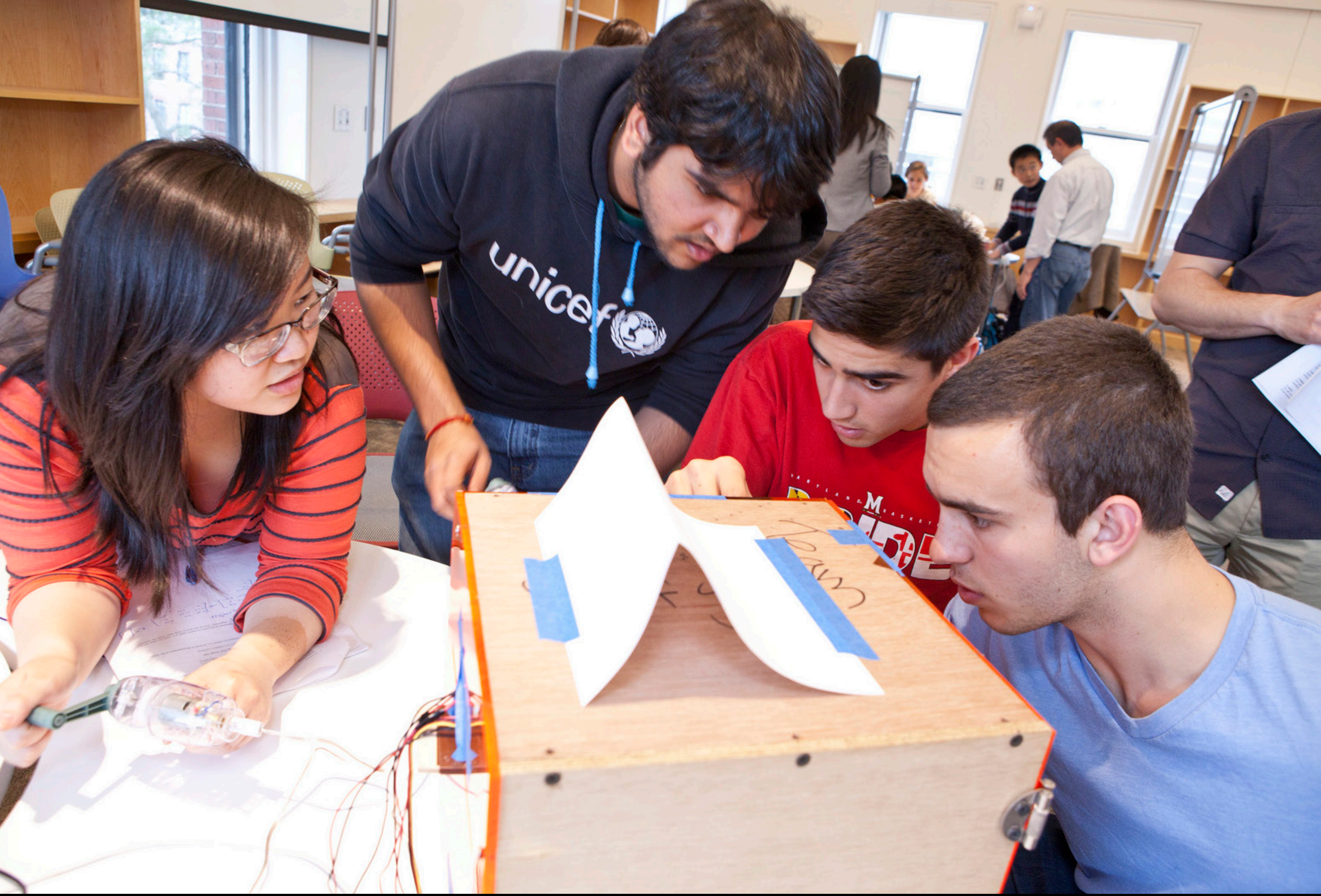
Projects

Milestones:

- team contract (at beginning)
- proposal (+1 week)
- fair (+3 weeks)
- report (+1 week +3 days for revision)
- team, peer, and self assessment (at end)

1 design

2 approach



1 design

2 approach

competition instead of

social good/empathy as motivator

1 design

2 approach

In-class activities

In-class activities

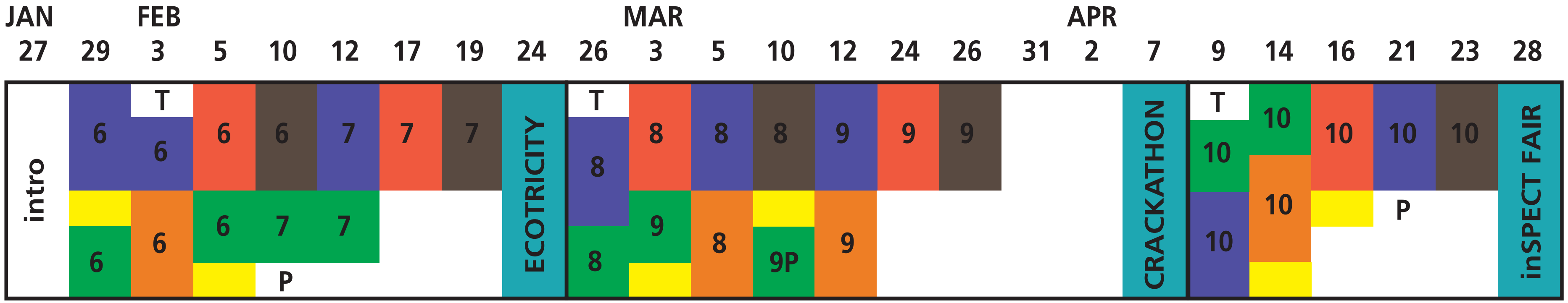
2 weekly 3-hour class periods

In-class activities

blend of 6 "best practices"

❶ design ❷ approach

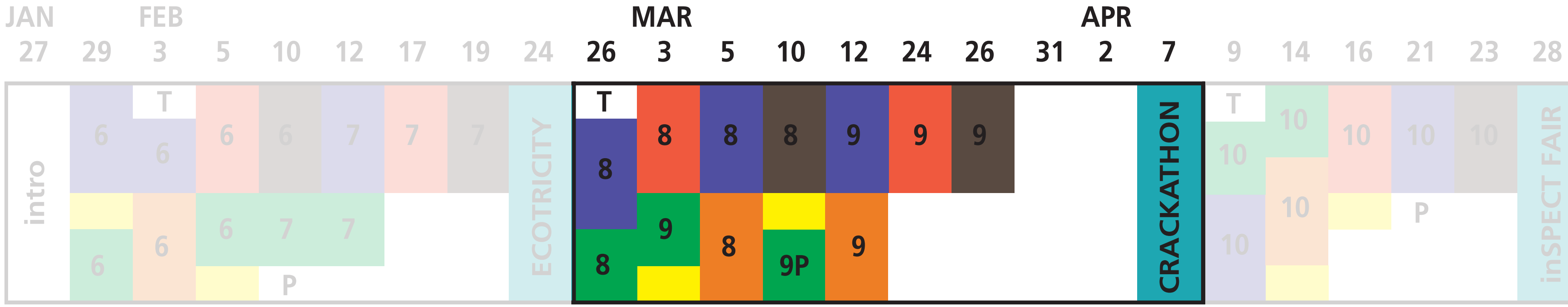
In-class activities



1 design
2 approach

In-class activities

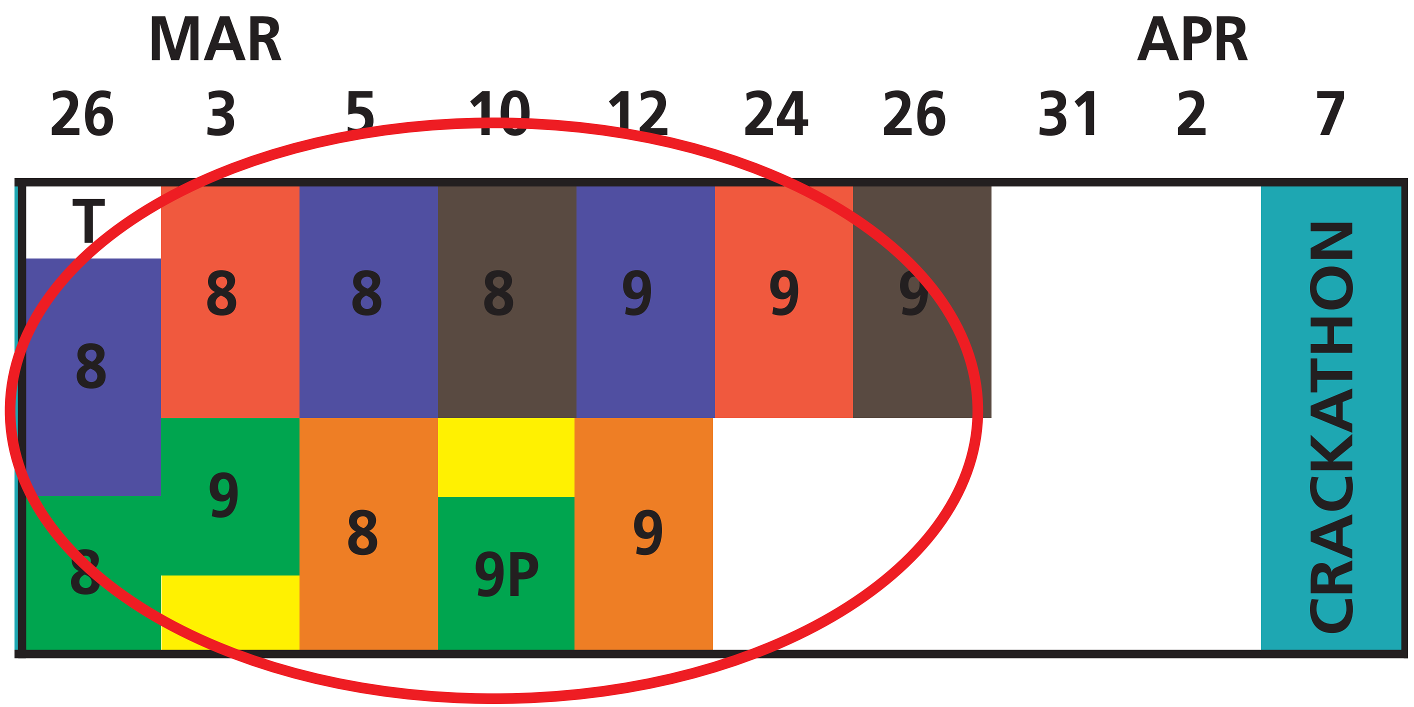
one project



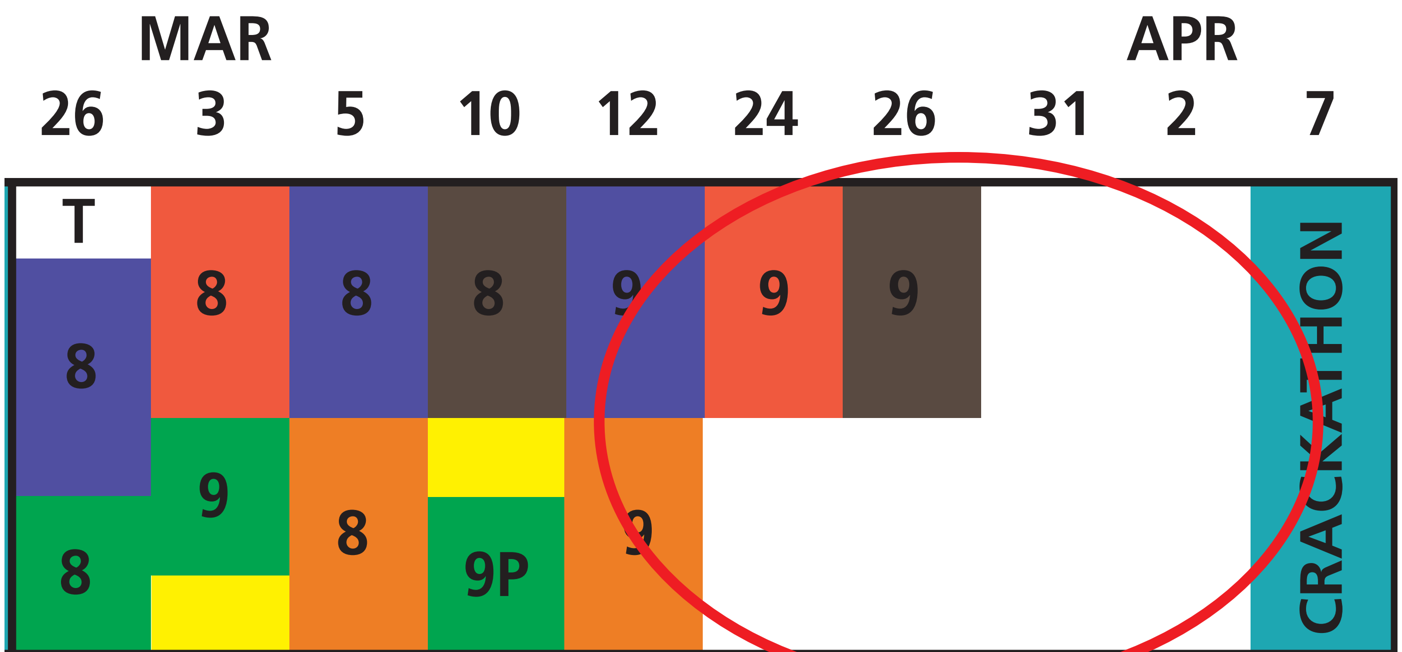
❶ design ❷ approach

In-class activities

2/3 scaffolded, guided



In-class activities



1/3 unguided

1 design 2 approach

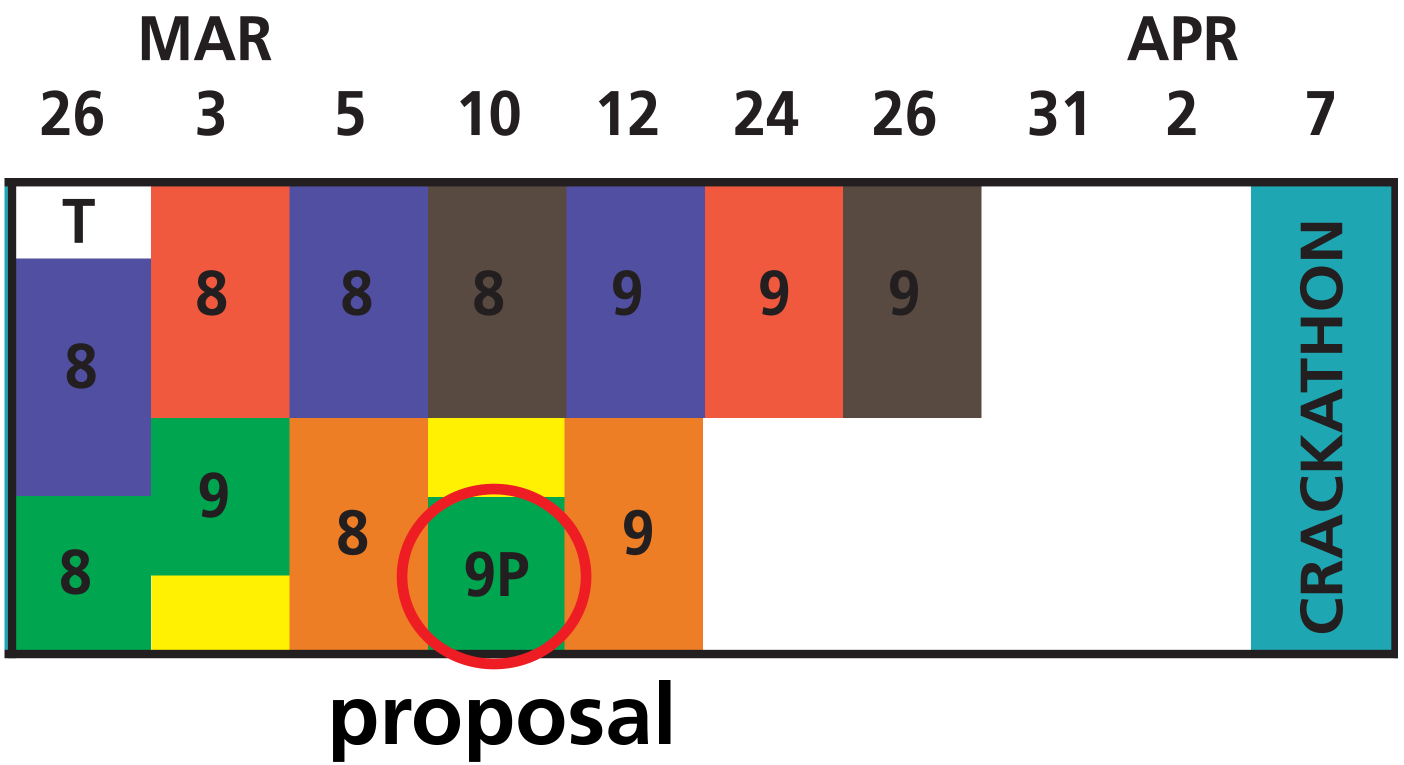
In-class activities

team intro

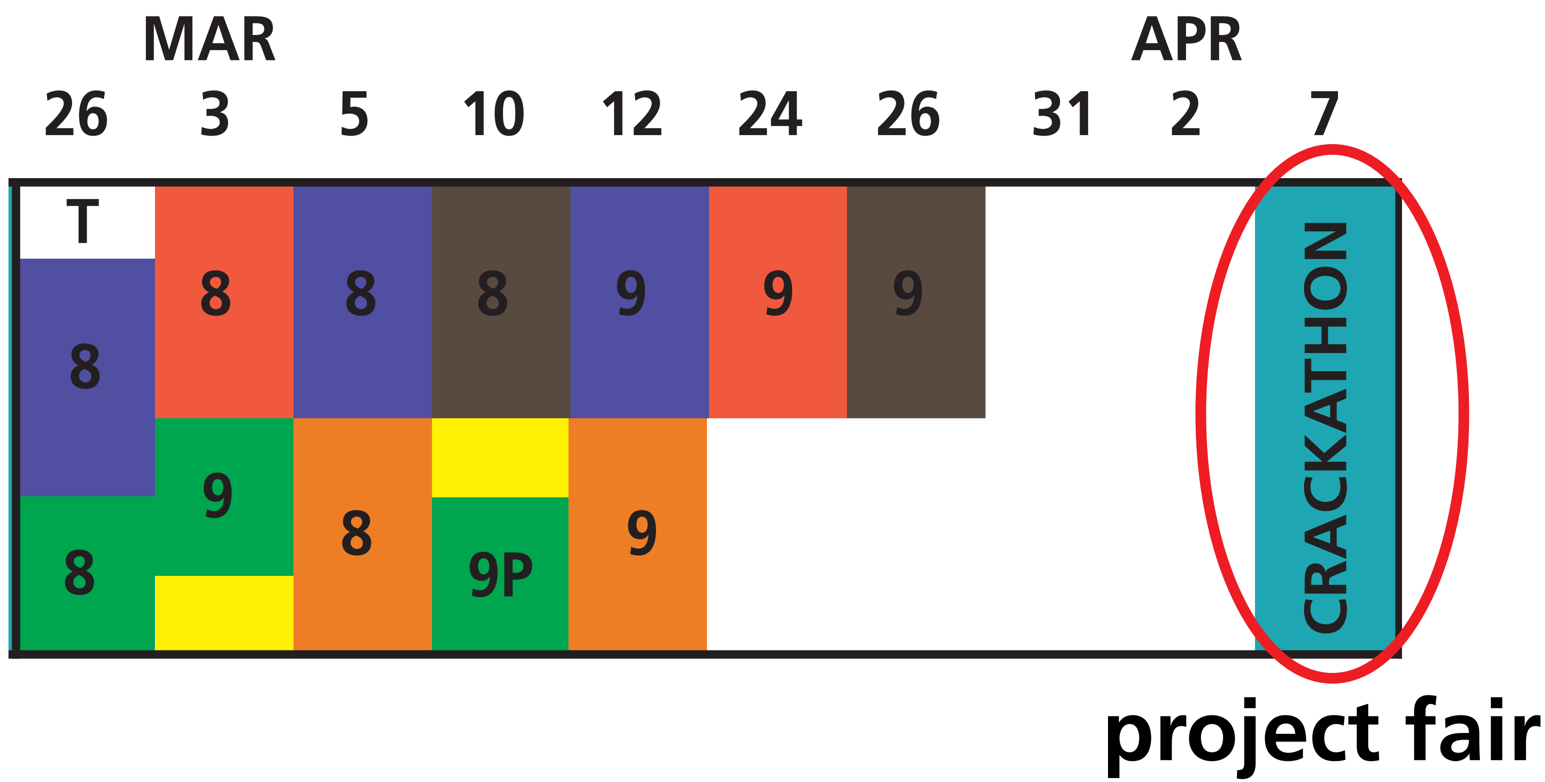
1 design

2 approach

In-class activities



In-class activities



1 design
2 approach

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

In-class activities

understand

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- Instructor poses question
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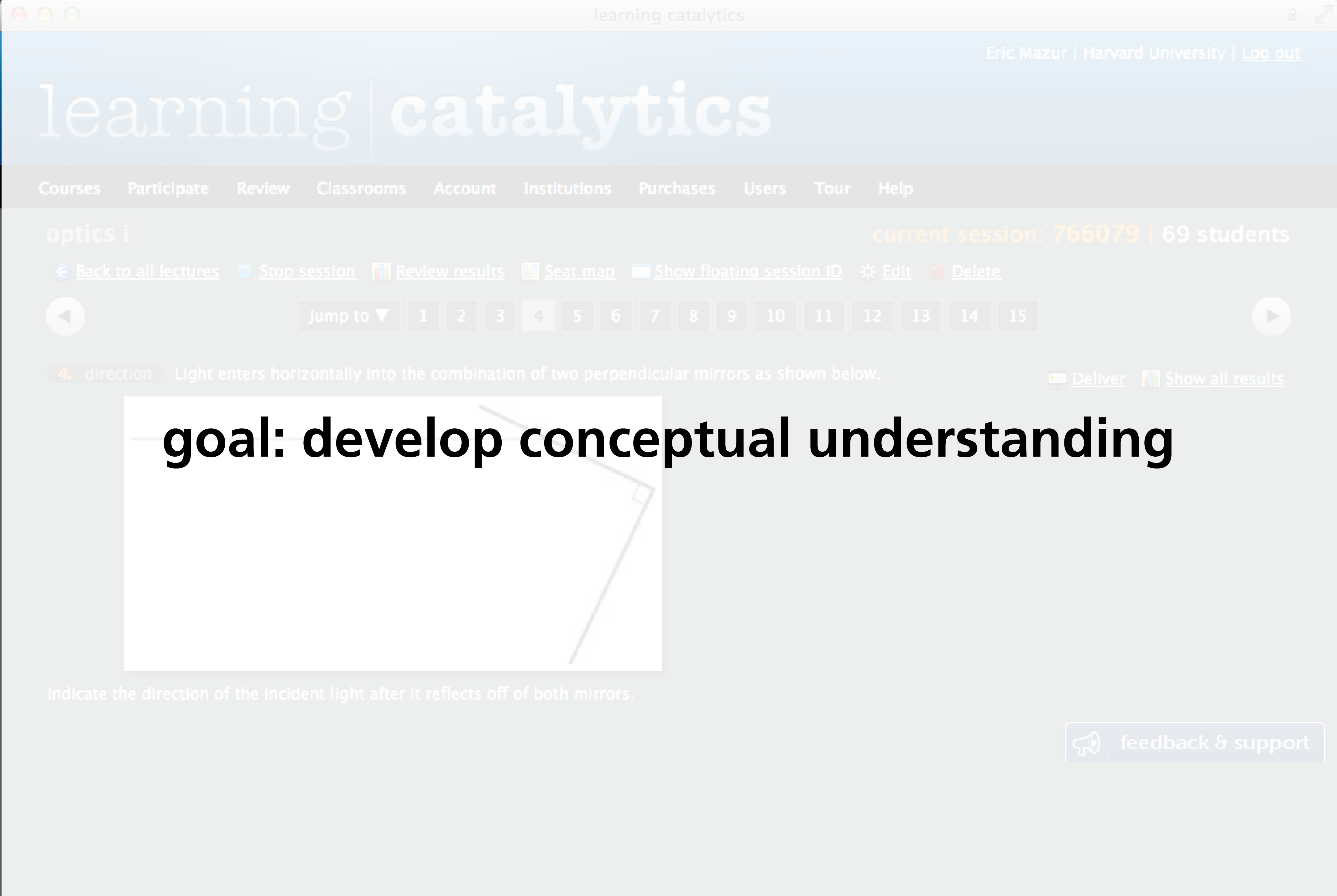
bring device

1 design   2 approach



goal: develop conceptual understanding

1 design

2 approach

Before we start, please sign on to Learning Catalytics using a web-enabled device (1 person/device):

1. Go to learningcatalytics.com/demo
2. Enter info, click “Start”
3. Join session 19557292

learning catalytics

Eric Mazur | Harvard University | Log out

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optics i

current session: 766079 | 69 students

Back to all lectures Stop session Review results Seat map Show floating session ID Edit Delete

Jump to ▼ 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

4. direction Light enters horizontally into the combination of two perpendicular mirrors as shown below.

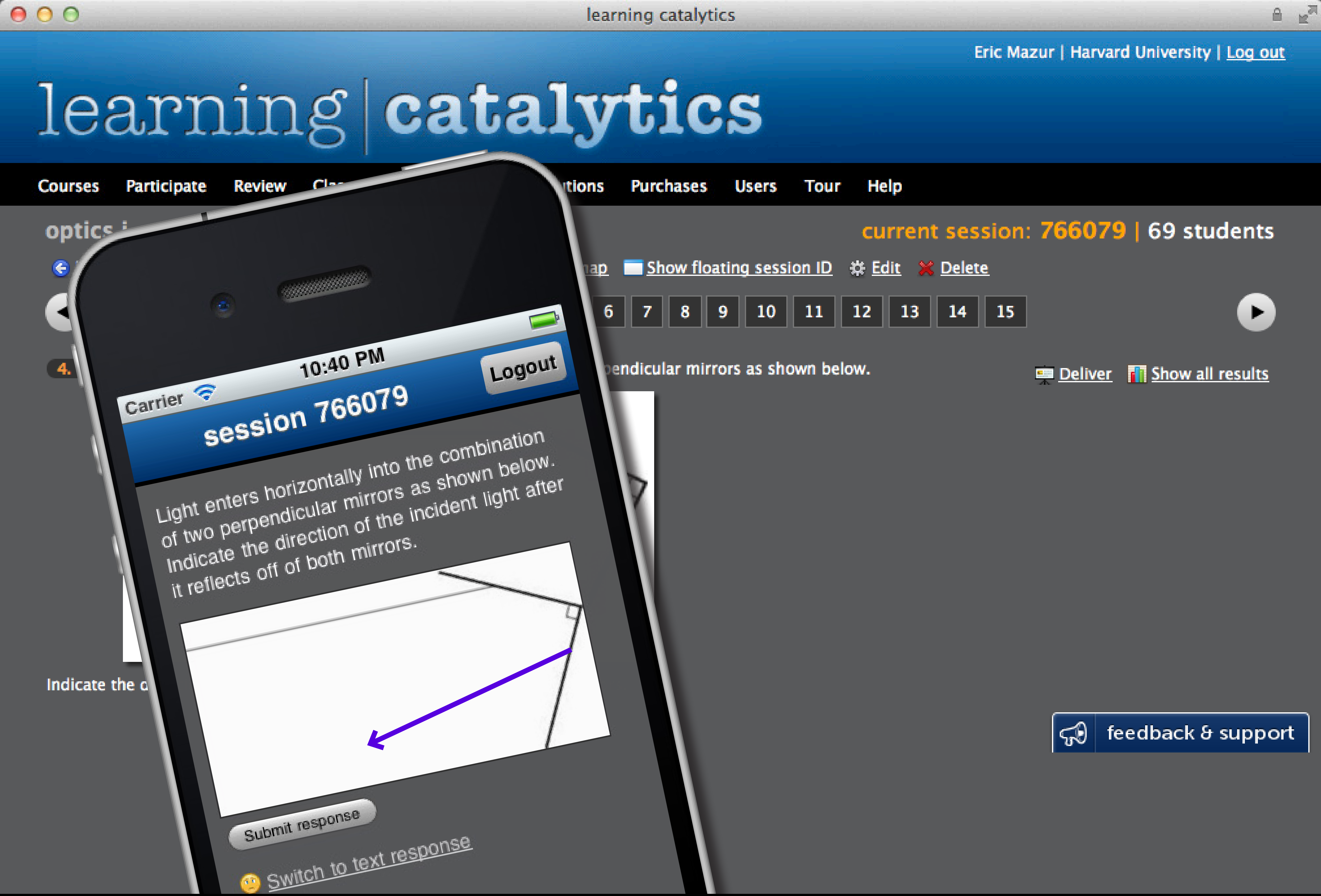
Deliver Show all results

Indicate the direction of the incident light after it reflects off of both mirrors.

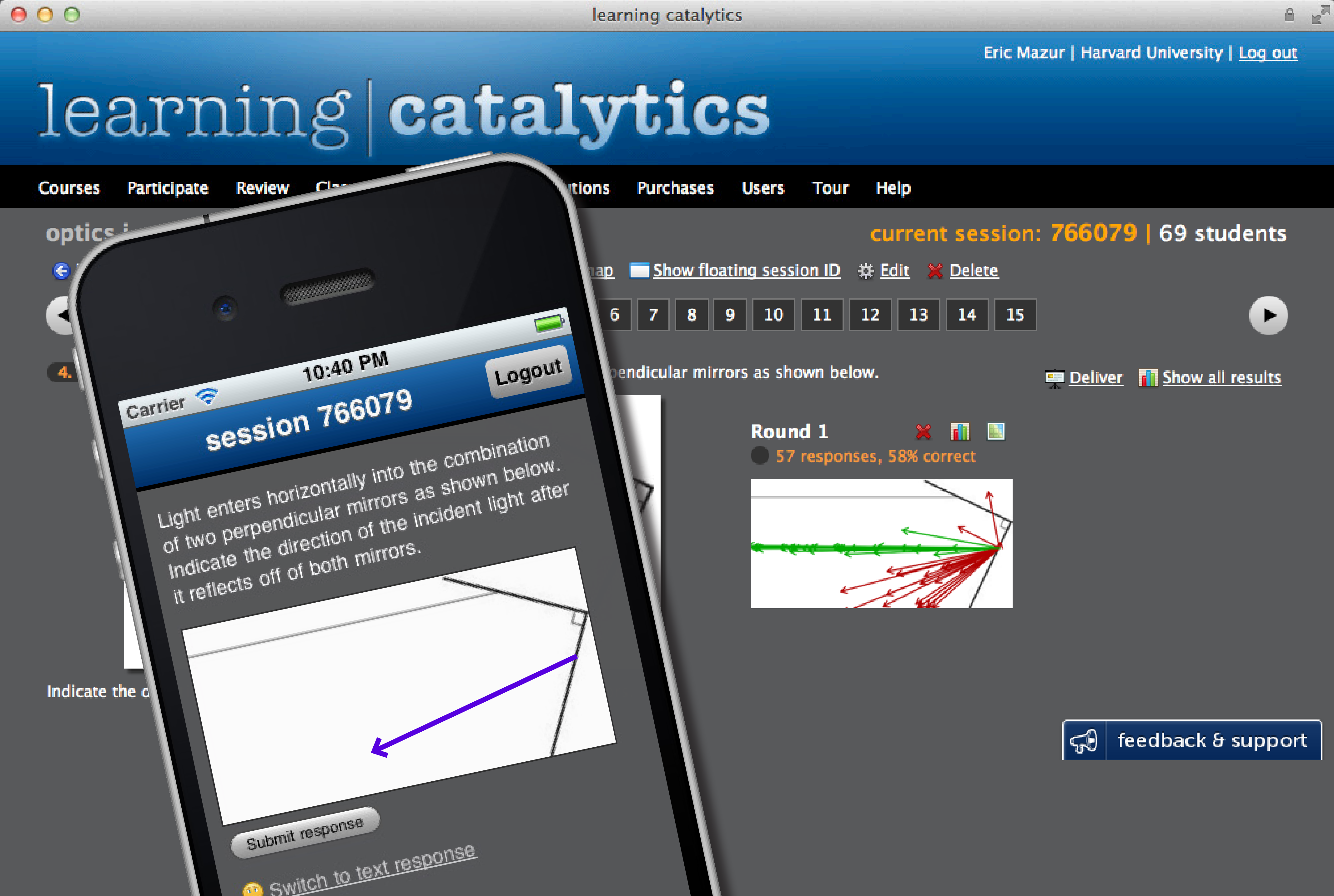
feedback & support

1 design 2 approach

1 design 2 approach

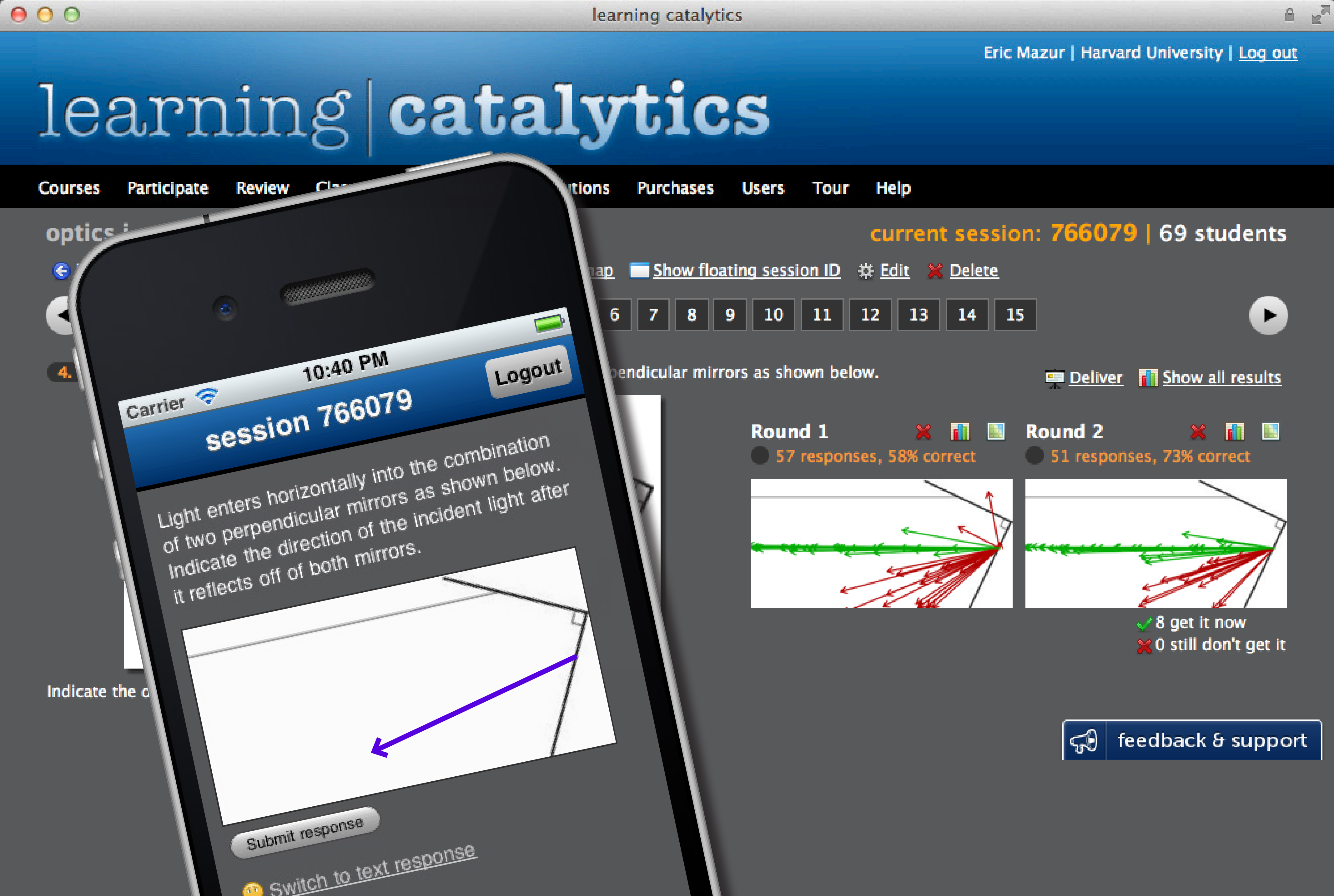


1 design 2 approach



1 design

2 approach



1 design 2 approach

In-class activities

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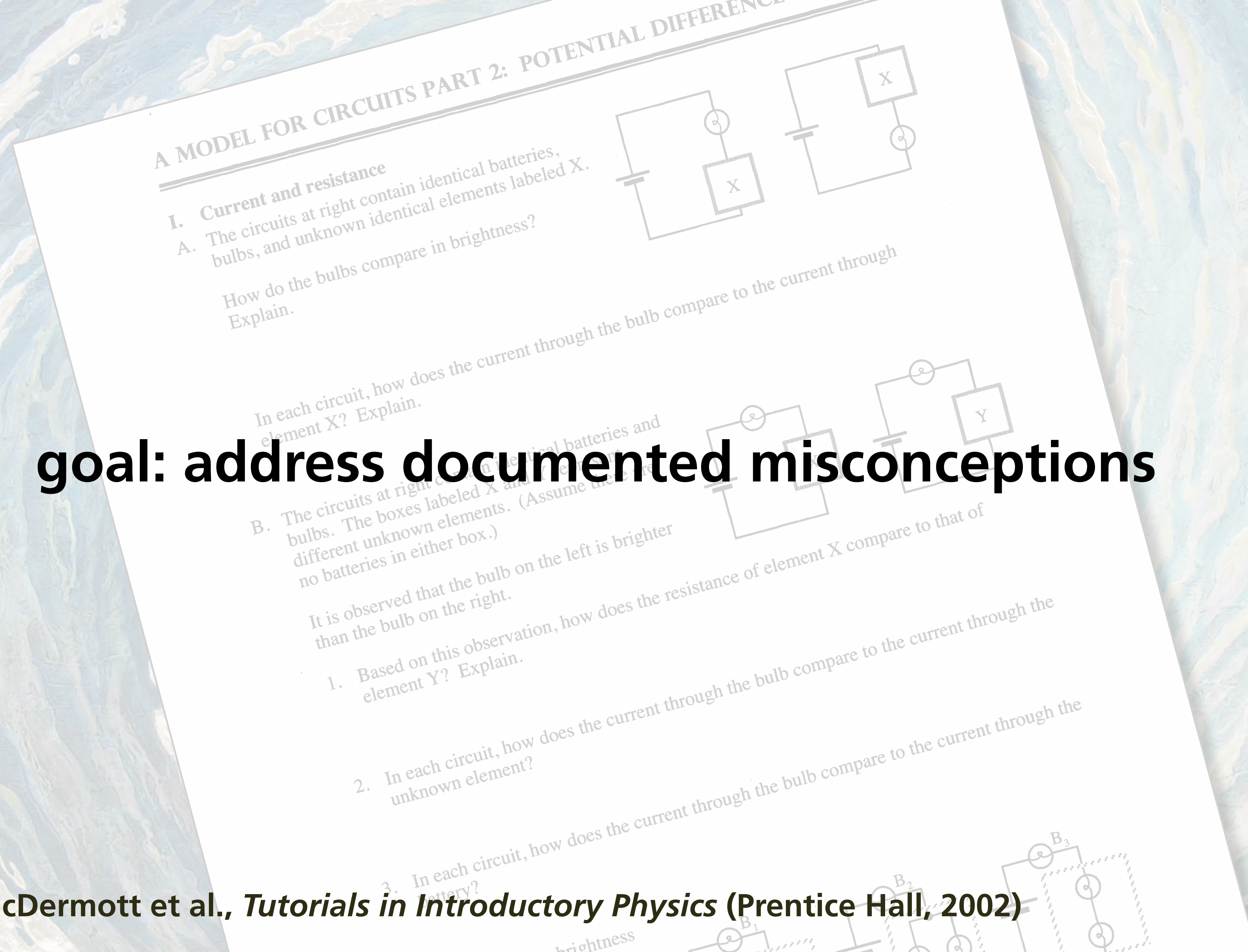
1 design   2 approach



A MODEL FOR CIRCUITS PART 2: POTENTIAL DIFFERENCE

I. Current and resistance

A. The circuits at right contain identical batteries, bulbs, and unknown identical elements labeled X.

How do the bulbs compare in brightness? Explain.

In each circuit, how does the current through the bulb compare to the current through element X? Explain.

B. The circuits at right contain identical batteries and bulbs. The boxes labeled X and Y contain different unknown elements. (Assume there are no batteries in either box.)

It is observed that the bulb on the left is brighter than the bulb on the right.

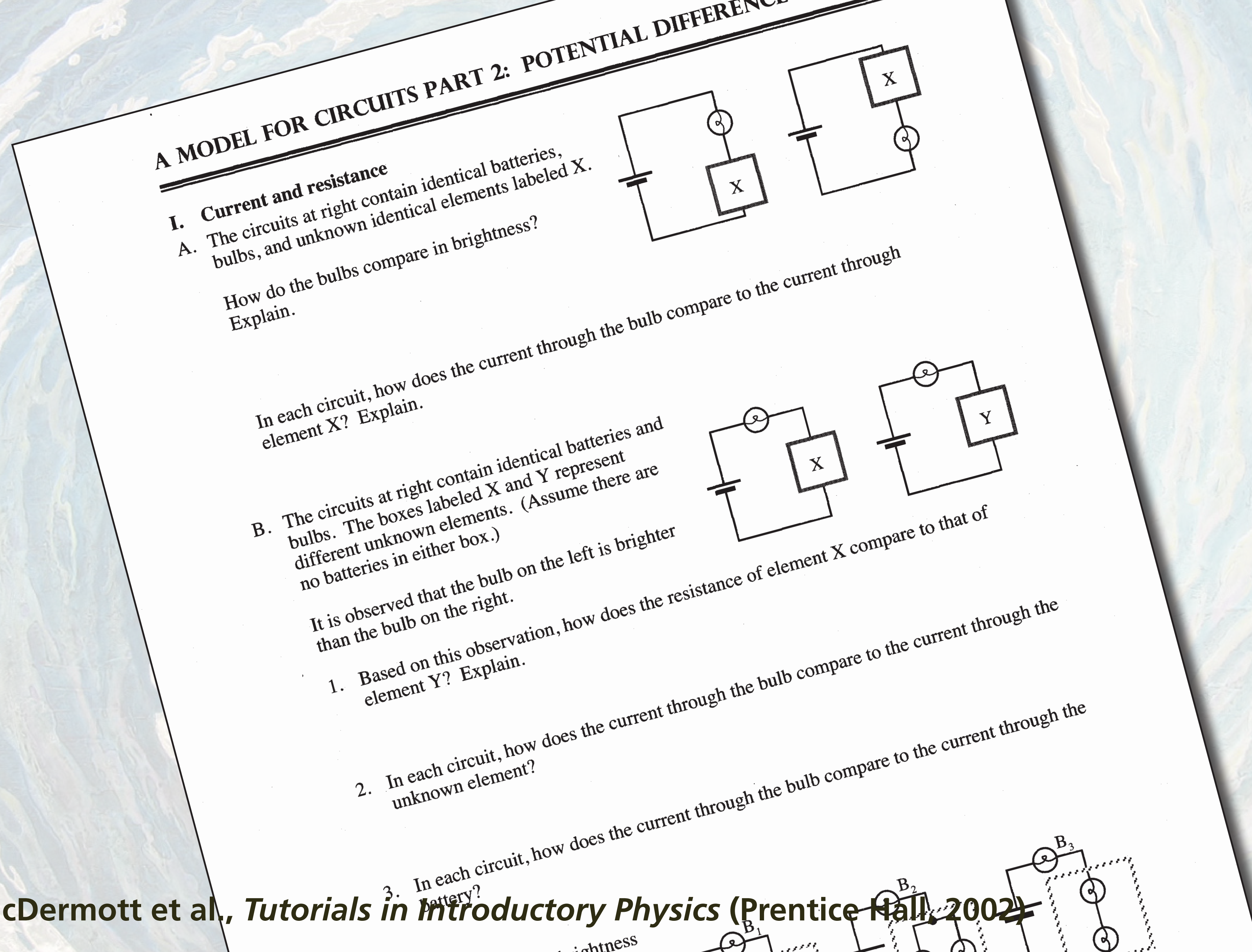
1. Based on this observation, how does the resistance of element X compare to that of element Y? Explain.

2. In each circuit, how does the current through the bulb compare to the current through the unknown element?

3. In each circuit, how does the current through the bulb compare to the current through the ttery?

goal: address documented misconceptions

McDermott et al., *Tutorials in Introductory Physics* (Prentice Hall, 2002)



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2. In each circuit, how does the current through the bulb compare to the current through the unknown element?

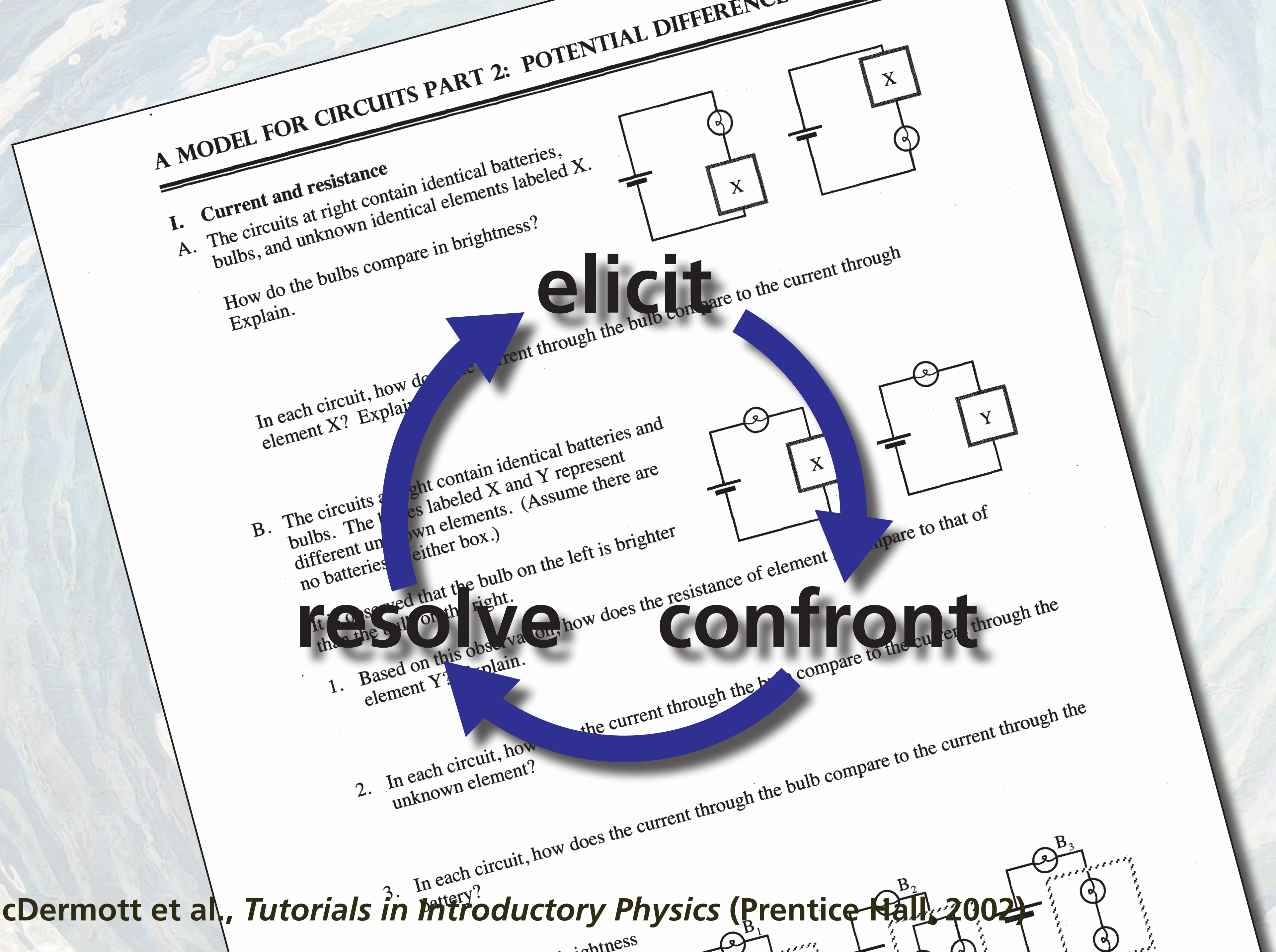
3. In each circuit, how does the current through the bulb compare to the current through the battery?

brightness

McDermott et al., *Tutorials in Introductory Physics* (Prentice Hall, 2002)

1 design

2 approach

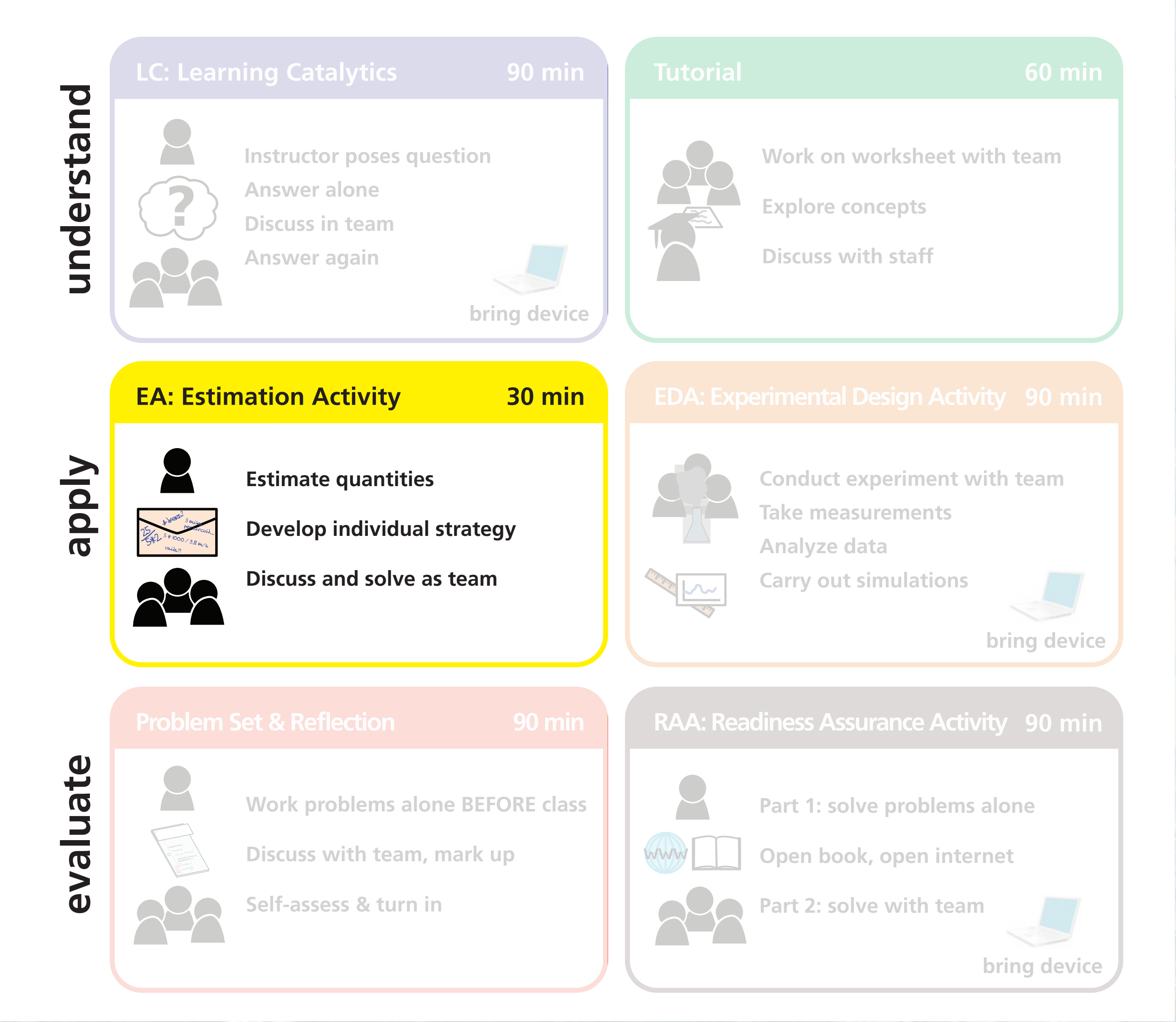


McDermott et al., *Tutorials in Introductory Physics* (Prentice Hall, 2002)

1 design

2 approach

In-class activities



1 design 2 approach


AP50 Fall 2014

Estimation Activity

Th Oct 9

Instructions: Estimate (not Guess or Google!) the quantities below to the nearest order of magnitude. Report all your answers as an order of magnitude (using the indicated units). Spend the first five minutes thinking *individually* about a strategy, then go at it with your team. You have 30 minutes exactly, so think fast!

When your team has completed all six questions, check your answers with a teaching staff member.

Important: Start from what you know; do not look up any values. Pretend you are being asked these questions at a job interview. Or you want to surprise people at a dinner party.

1. Estimate the chemical energy released during the explosive separation of a professional fireworks shell. Answer units: [J]
2. Estimate the relative speed of the moon as seen from an observer on the earth. Answer units: [m/s]
3. Estimate the power output by an average person completing a "stadium workout" where they run up and down the 30 sections of the Harvard Stadium as fast as they can. Answer units: [W]
4. Estimate the force of the atmosphere exerted on the entire surface of one person's skin. Answer units: [N]
5. Estimate the height of the mountain a college student could climb with the energy saved by turning out their dorm lights instead of keeping the lights on for an all-nighter homework assignment. Answer units: [m]

goal: develop qualitative reasoning skills

1 design

2 approach

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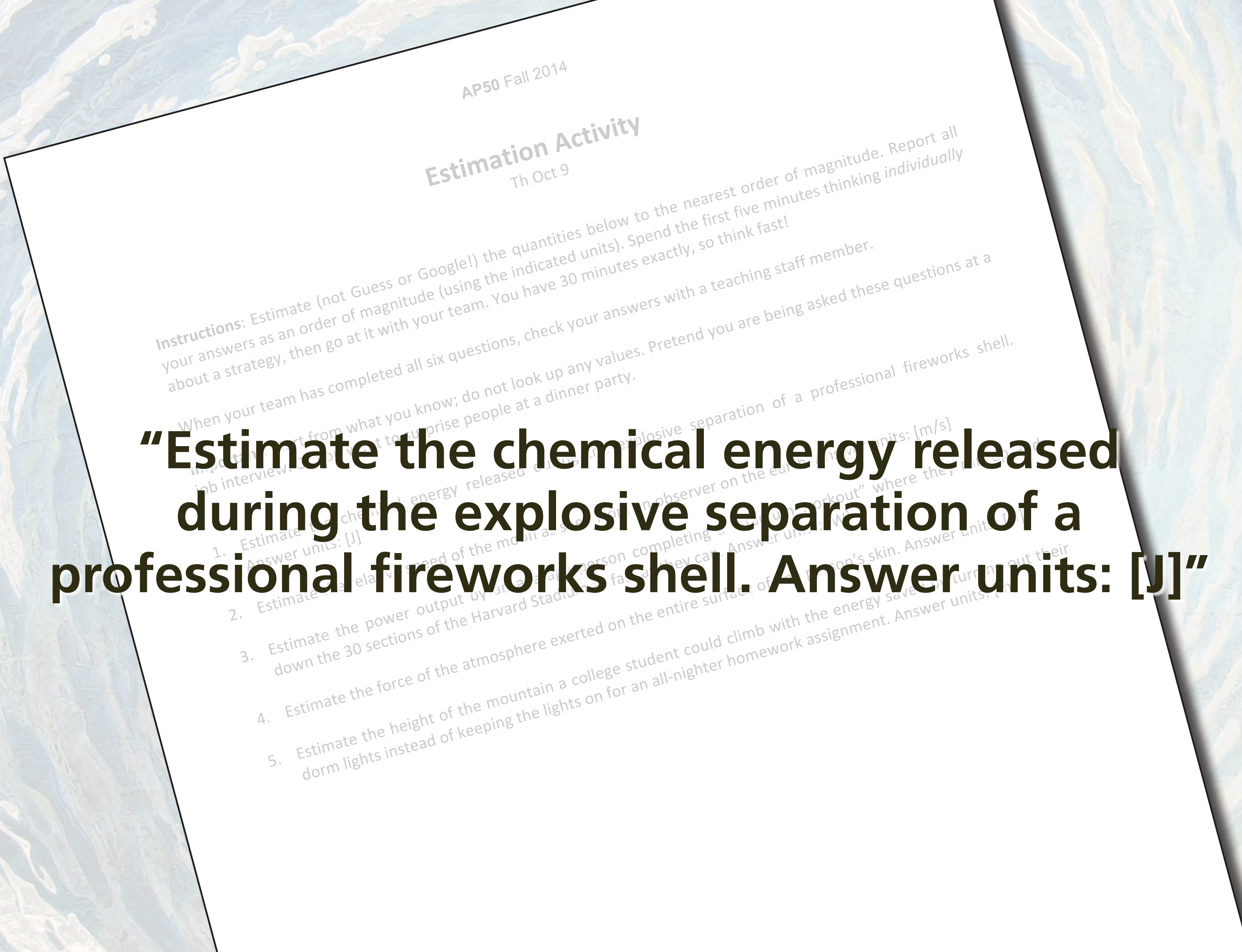
1 design

2 approach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3. Estimate the power output by [illegible] person completing [illegible] workout" where they [illegible] down the 30 sections of the Harvard Stadium [illegible]
4. Estimate the force of the atmosphere exerted on the entire surface of [illegible] person's skin. Answer units: [illegible]
5. Estimate the height of the mountain a college student could climb with the energy saved [illegible] turning out their dorm lights instead of keeping the lights on for an all-nighter homework assignment. Answer units: [illegible]

"Estimate the chemical energy released during the explosive separation of a professional fireworks shell. Answer units: [J]"

1 design **2 approach**

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

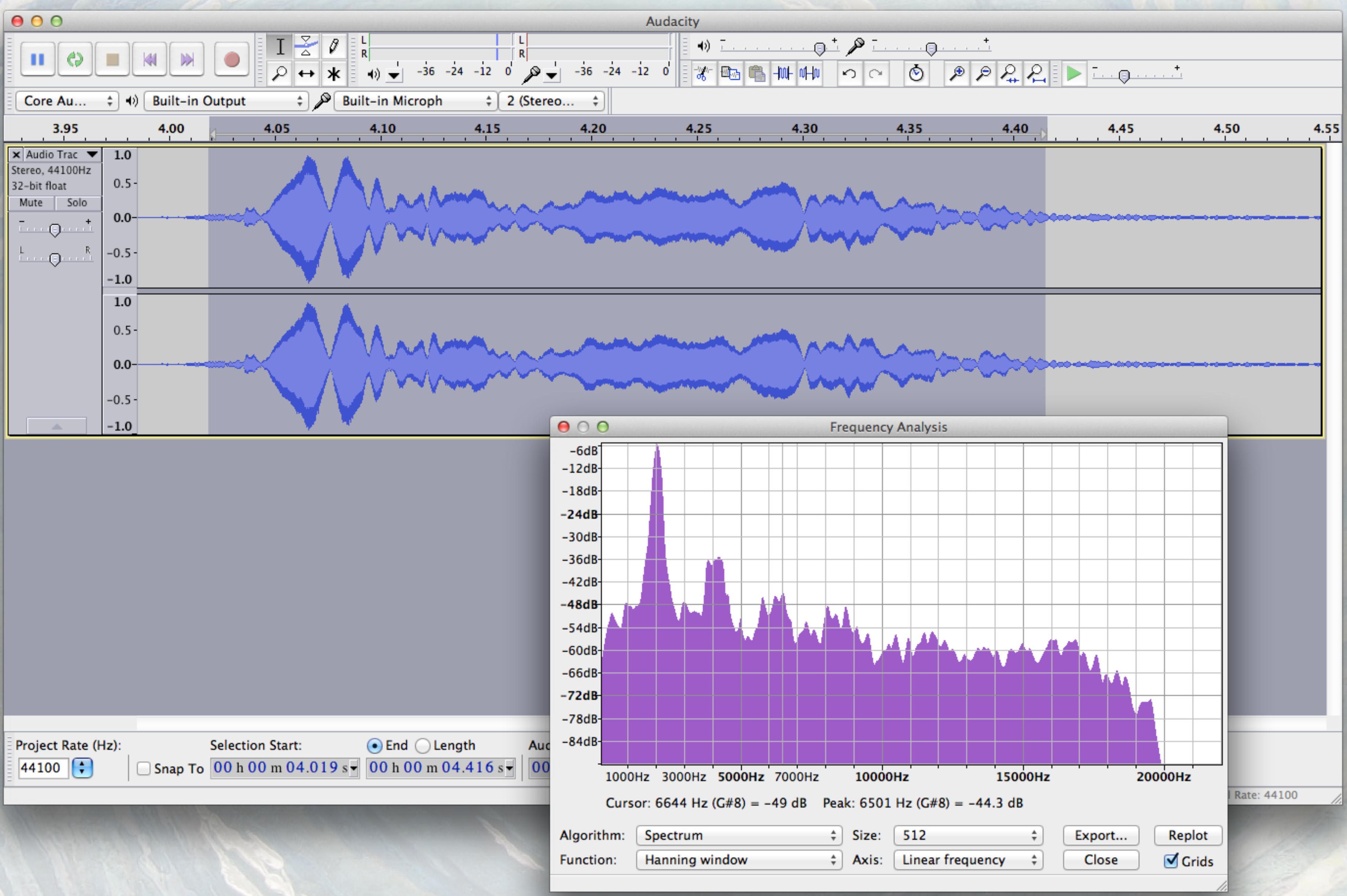
RAA: Readiness Assurance Activity — 90 min
- Part 1: solve problems alone
- Open book, open internet
- Part 2: solve with team

bring device

1 design

2 approach

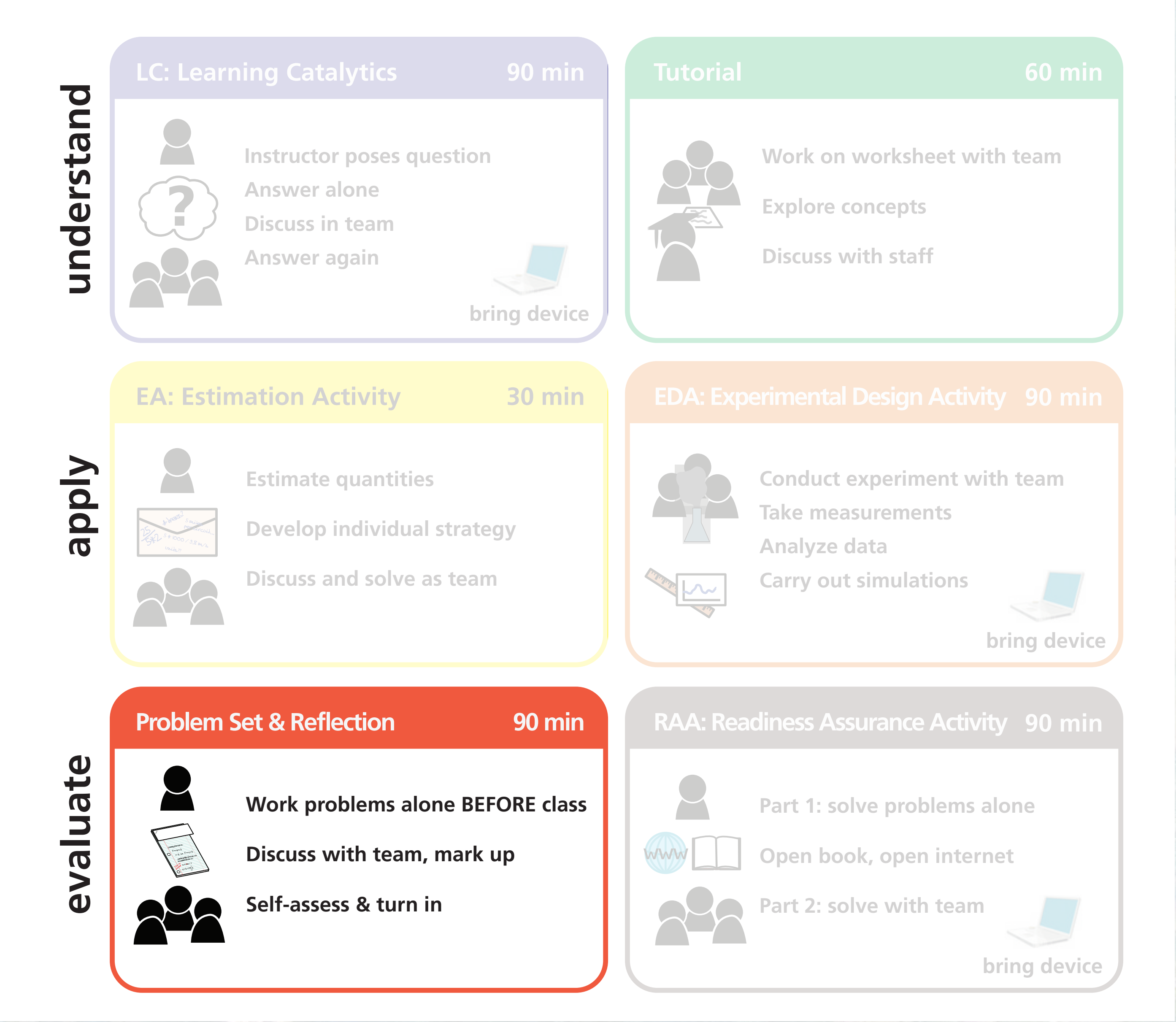
goal: develop experimental skills



1 design

2 approach

In-class activities



1 design 2 approach

AP50b Fall 2013

Problem Set 1

due W Feb 6 in class

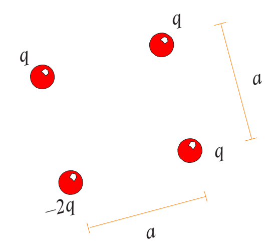
Instructions: as we need to quickly scan your work so we can return it before the end of class, please:

- 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.

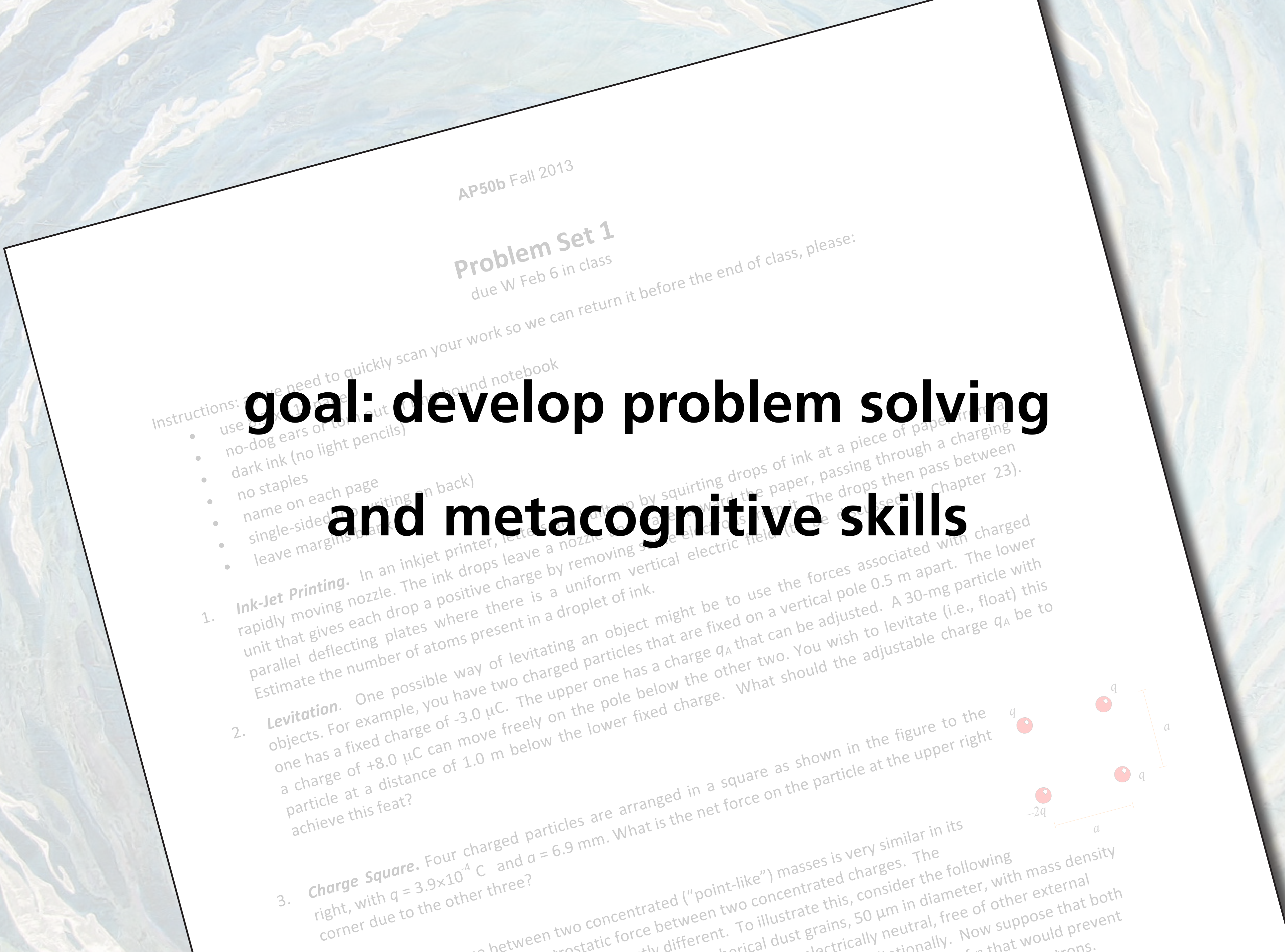
2. ***Levitation***. One possible way of levitating an object might be to use the forces associated with charged objects. For example, you have two charged particles that are fixed on a vertical pole 0.5 m apart. The lower one has a fixed charge of -3.0 μC. The upper one has a charge q_A that can be 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 … electrostatic 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



AP50b Fall 2013

Problem Set 1

due W Feb 6 in class

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- use [illegible] bound notebook
- no-dog ears or [illegible]
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- name on each page
- single-sided [illegible] on back)
- leave margins [illegible]

1. ***Ink-Jet Printing.*** In an inkjet printer, [illegible] by squirting drops of ink at a piece of paper [illegible] rapidly moving nozzle. The ink drops leave a nozzle [illegible] the paper, passing through a charging unit that gives each drop a positive charge by removing [illegible]. The drops then pass between parallel deflecting plates where there is a uniform vertical electric field [illegible] Chapter 23). Estimate the number of atoms present in a droplet of ink.

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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

AP50 Spring 2015

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. During this stage, you may only use **red ink** to write on your problem sets (pens will be provided in class) ... 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... onl...

1 design

2 approach

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1 design

2 approach

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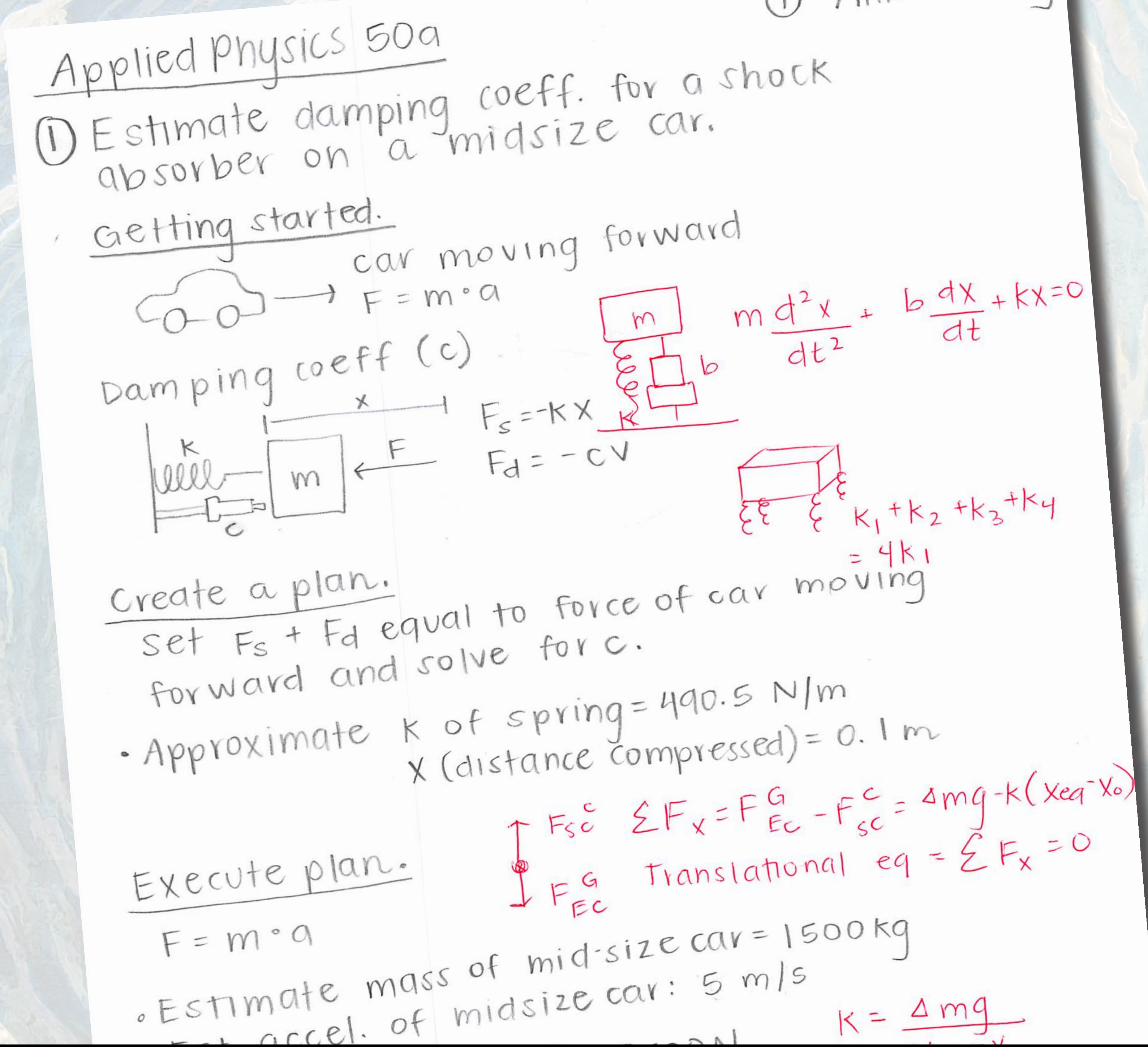
at home:

implement 4-step procedure

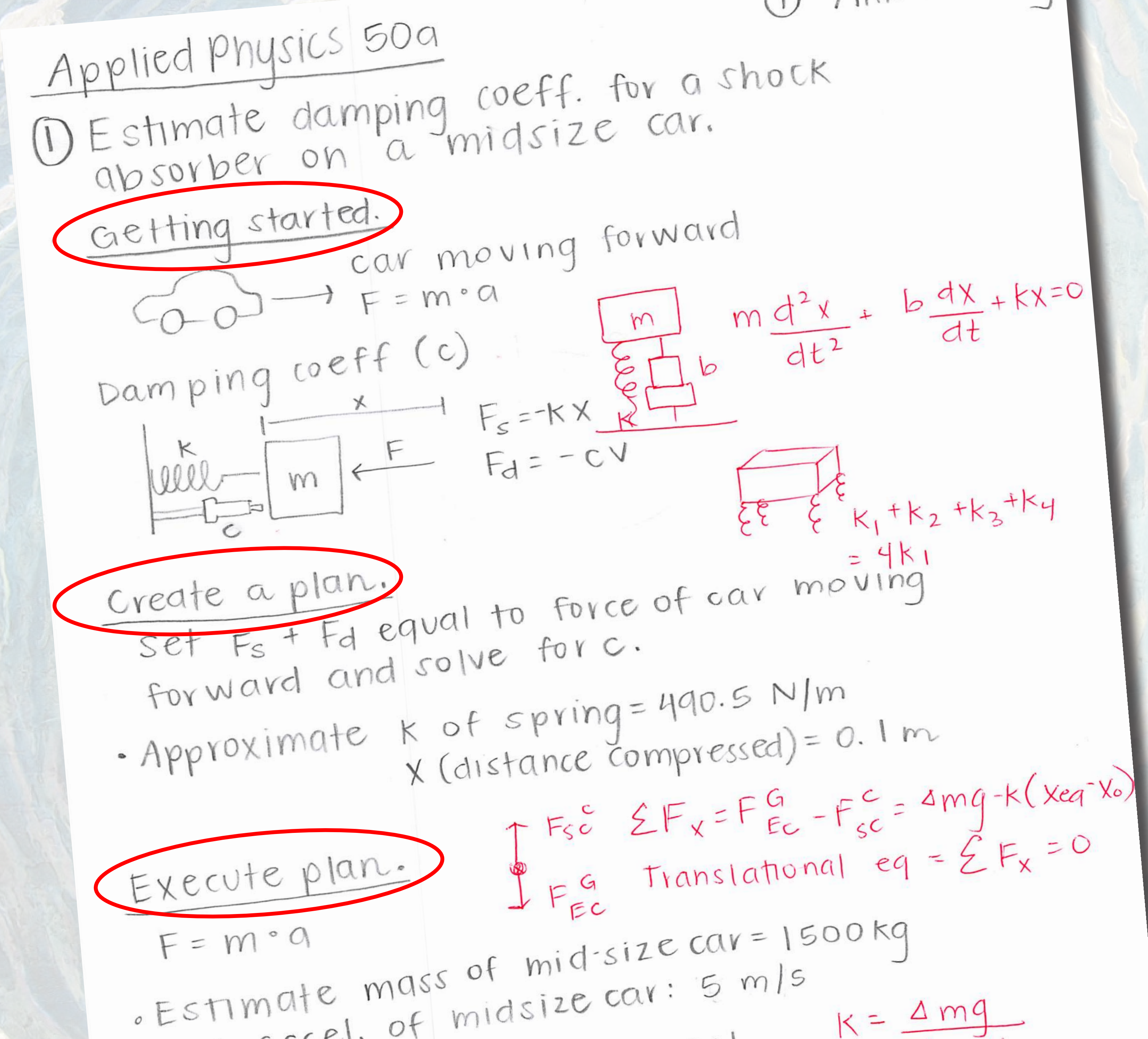
(evaluated on effort)

1 design

2 approach



1 design **2** approach



Applied Physics 50a

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

Getting started.

car moving forward

$F = m \cdot a$

Damping coeff (c)

$F_s = -kx$

$F_d = -cv$

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

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

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

$\sum F_x = F^G_{EC} - F^C_{SC} = \Delta mg - k(x_{eq} - x_0)$

Translational eq = $\sum F_x = 0$

Execute plan.

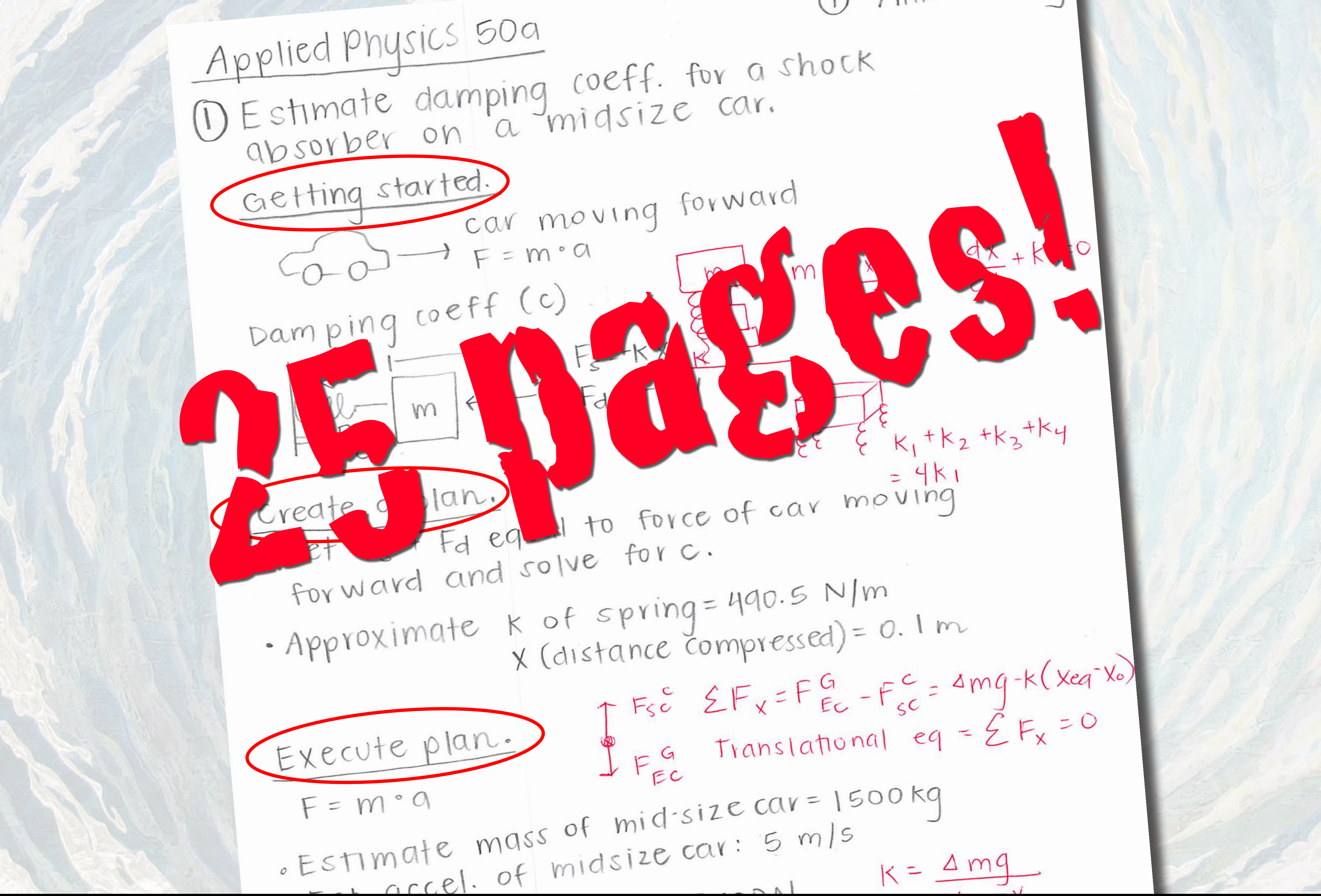
$F = m \cdot a$

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

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

1 design

2 approach



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

1 design   2 approach

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in class:

mark up/improve solutions

complete reflection 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.

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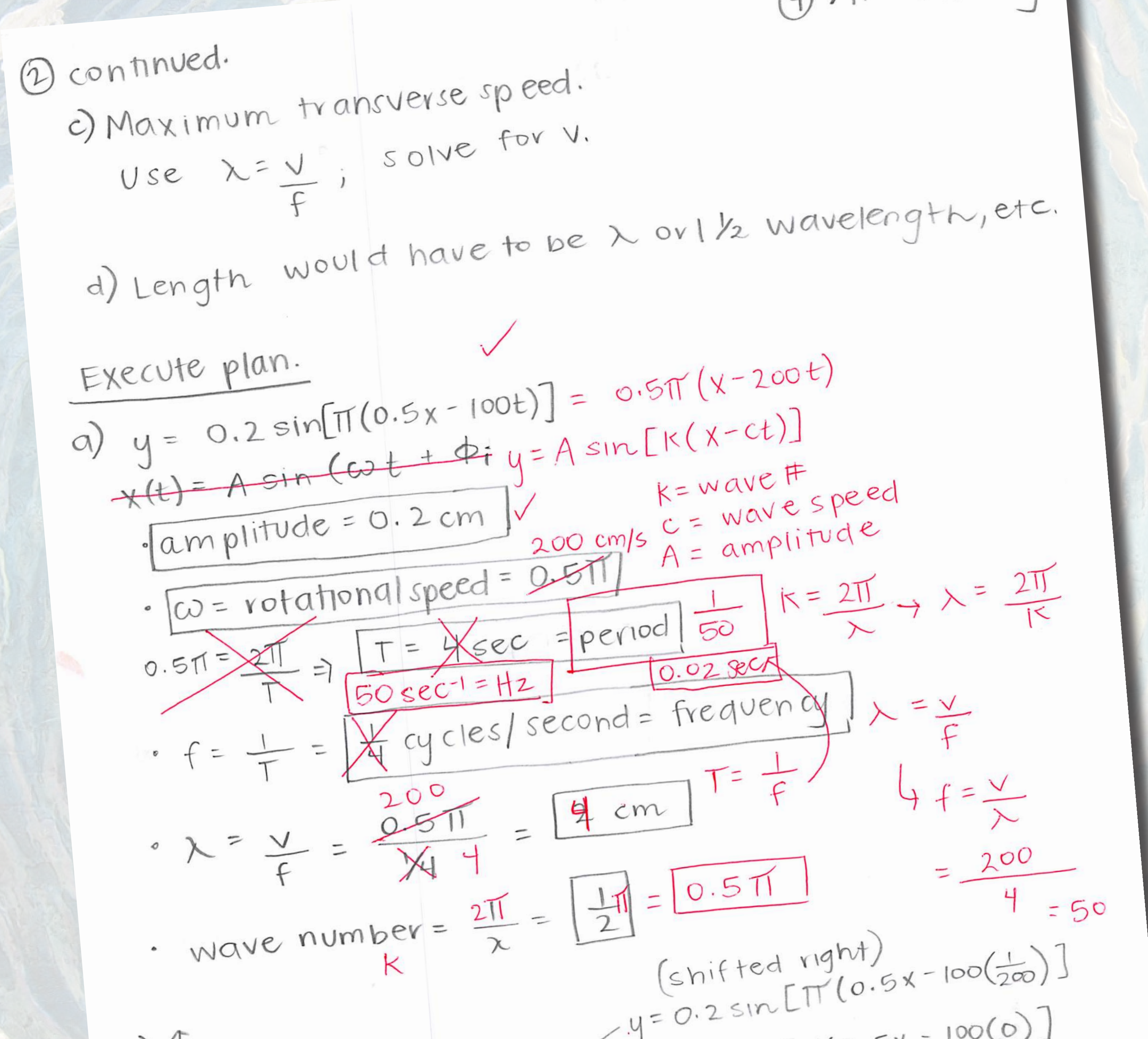
1 design   2 approach



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

• amplitude = 0.2 cm ✓

• ω = rotational speed = ~~0.5π~~ 200 cm/s

~~$0.5\pi = \frac{2\pi}{T}$~~ ⇒ T = ~~4~~ sec = period $\frac{1}{50}$ 0.02 sec

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

• $f = \frac{1}{T}$ = ~~$\frac{1}{4}$~~ cycles/second = frequency

• $\lambda = \frac{v}{f} = \frac{\text{~~0.5π~~ } 200}{\text{~~1/4~~ } 4}$ = ~~4~~ 4 cm

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

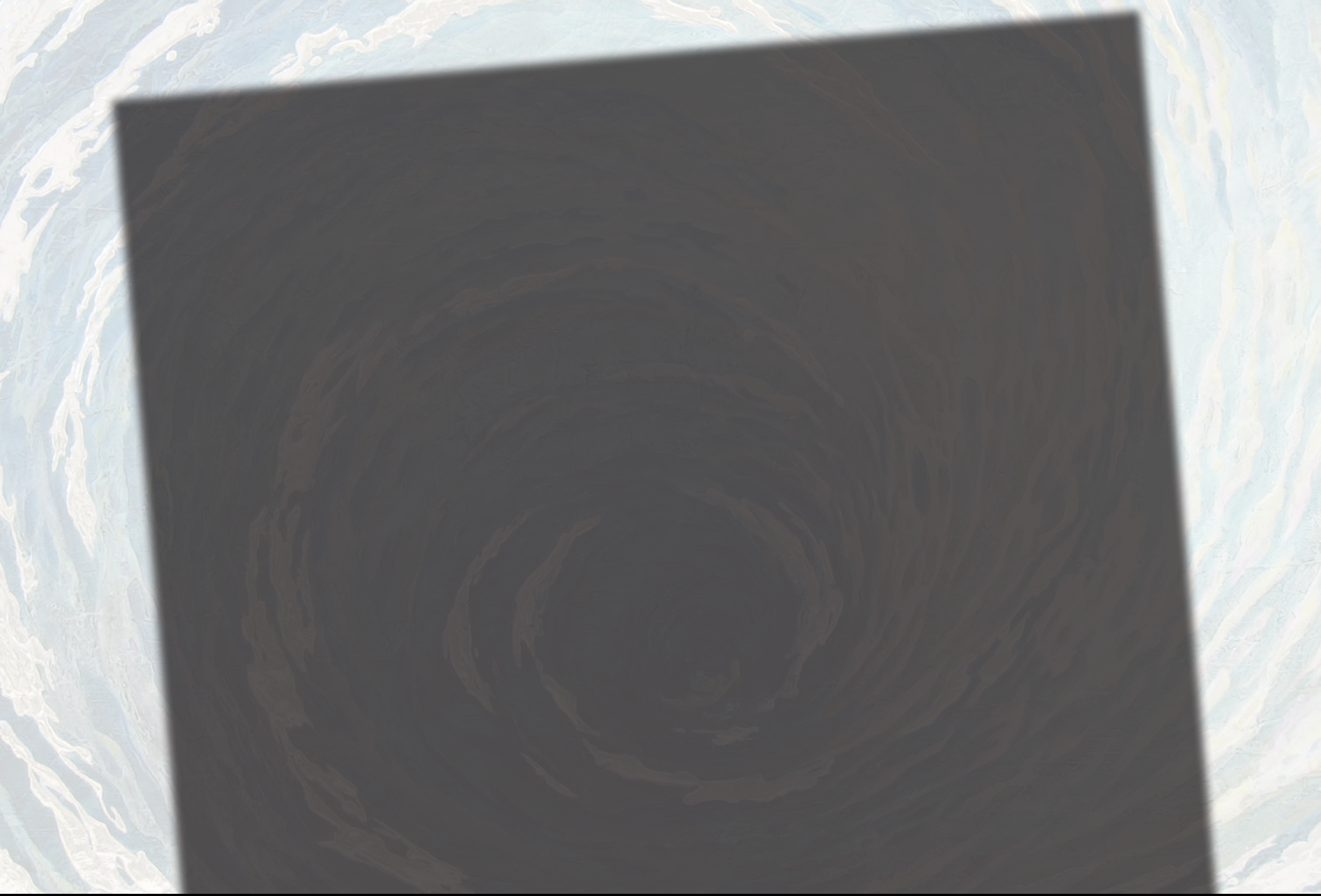
$k = \frac{2\pi}{\lambda} \rightarrow \lambda = \frac{2\pi}{k}$

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

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

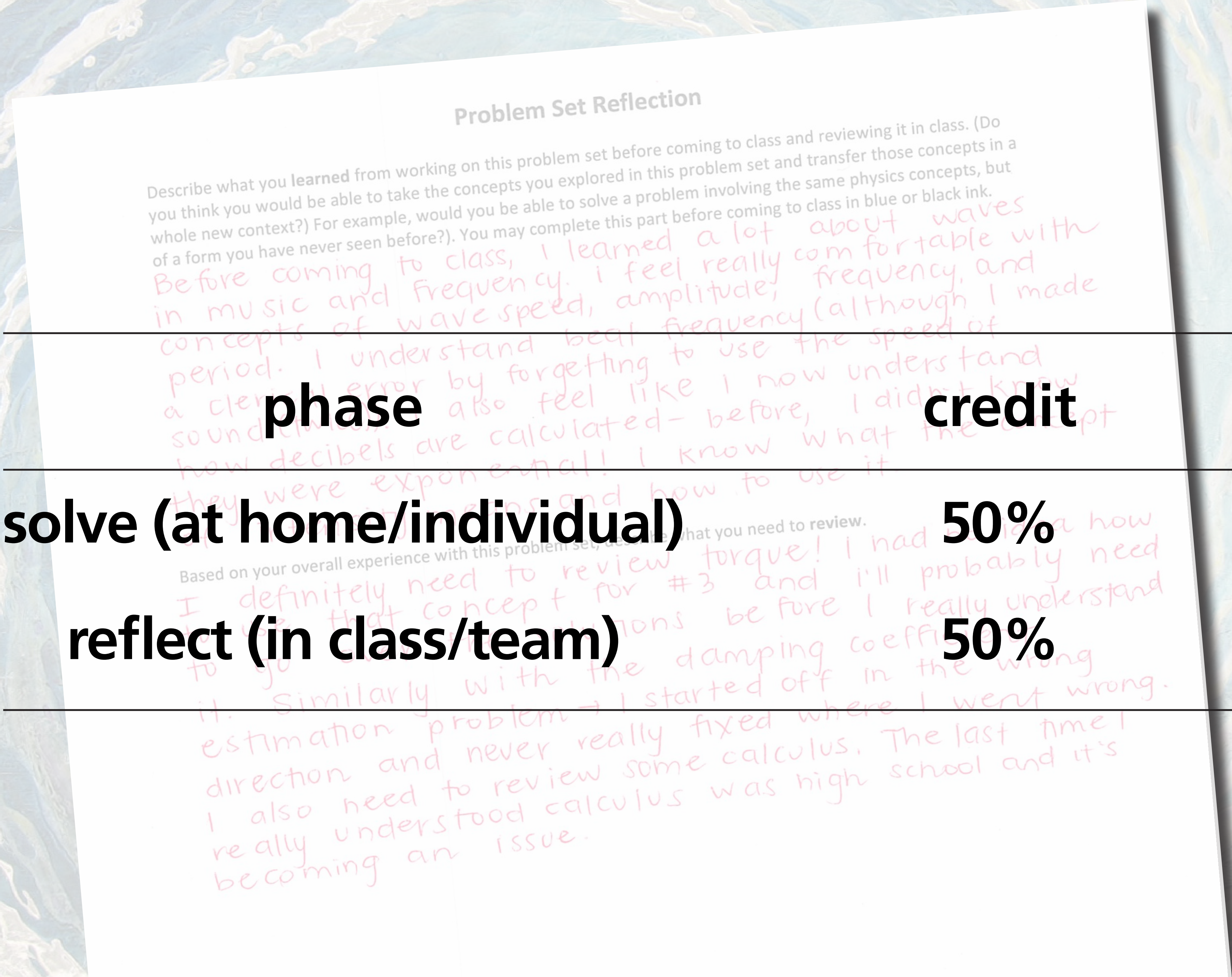
(shifted right)
$y = 0.2 \sin[\pi(0.5x - 100(\frac{1}{200}))]$
$[\pi(0.5x - 100(0))]$

1 design **2 approach**



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
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- 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

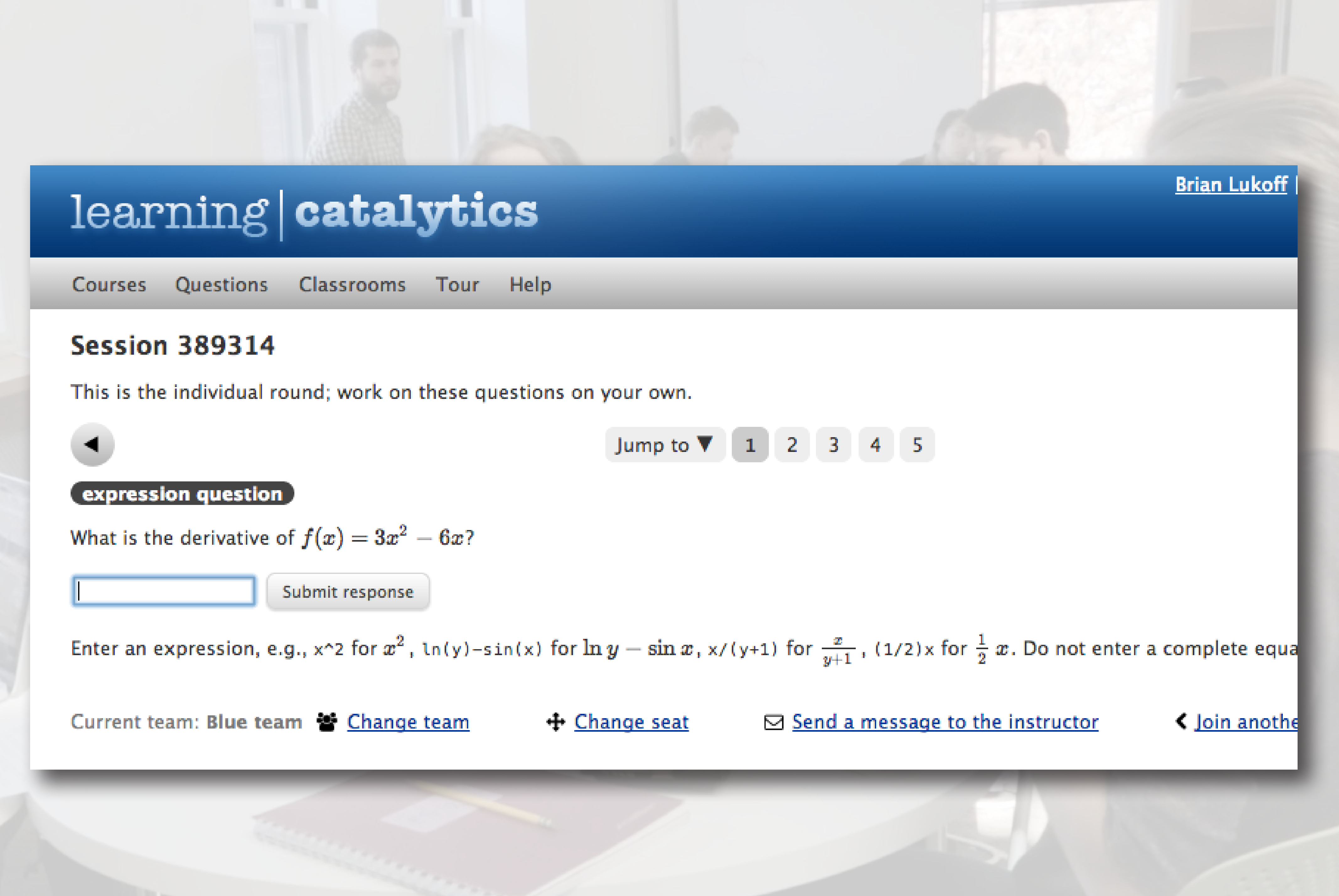
1 design

2 approach

goal: formative assessment

collaborative learning

1 design **2 approach**



1 design

2 approach

This is the individual round;

expression question

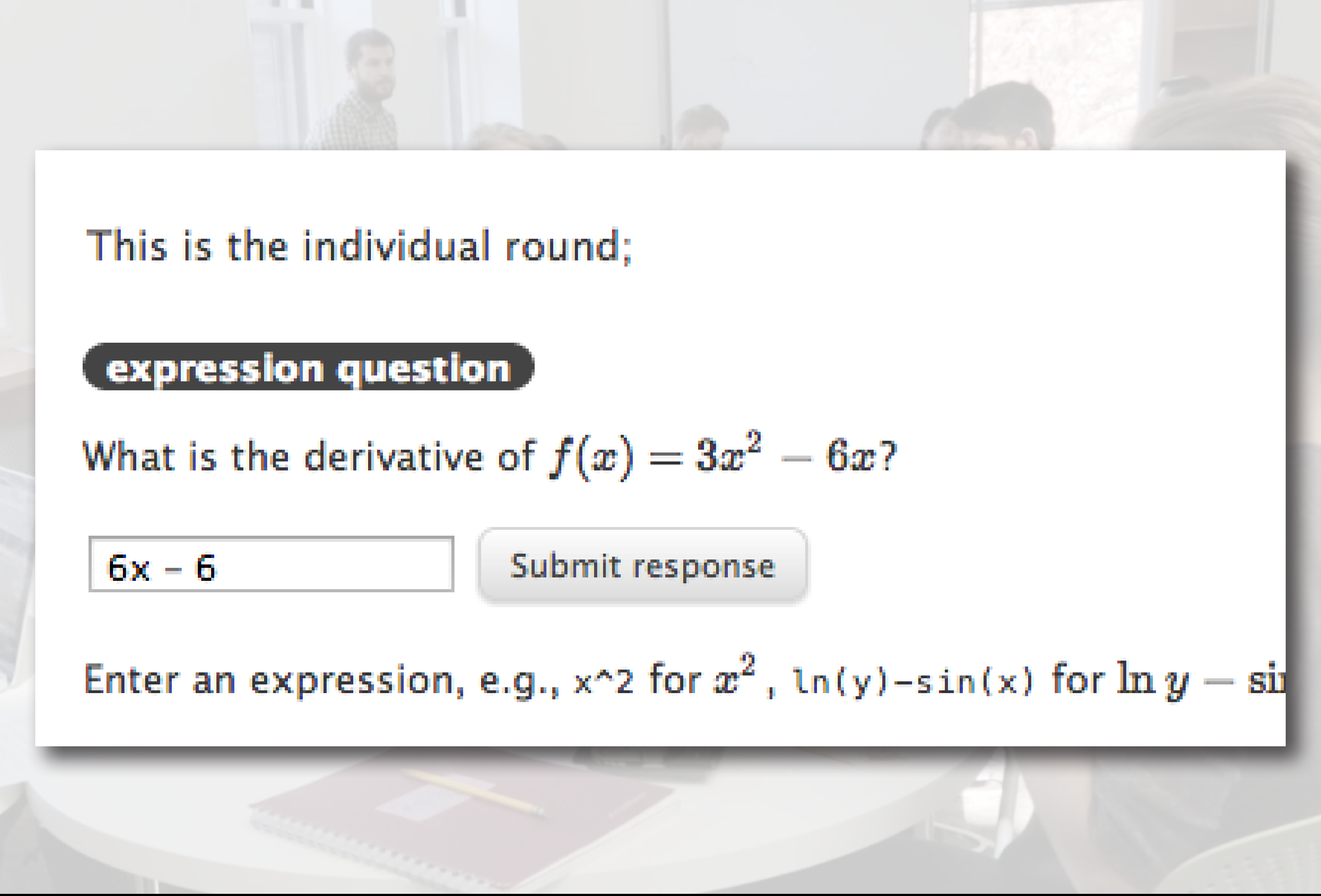
What is the derivative of $f(x) = 3x^2 - 6x$?

Submit response

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

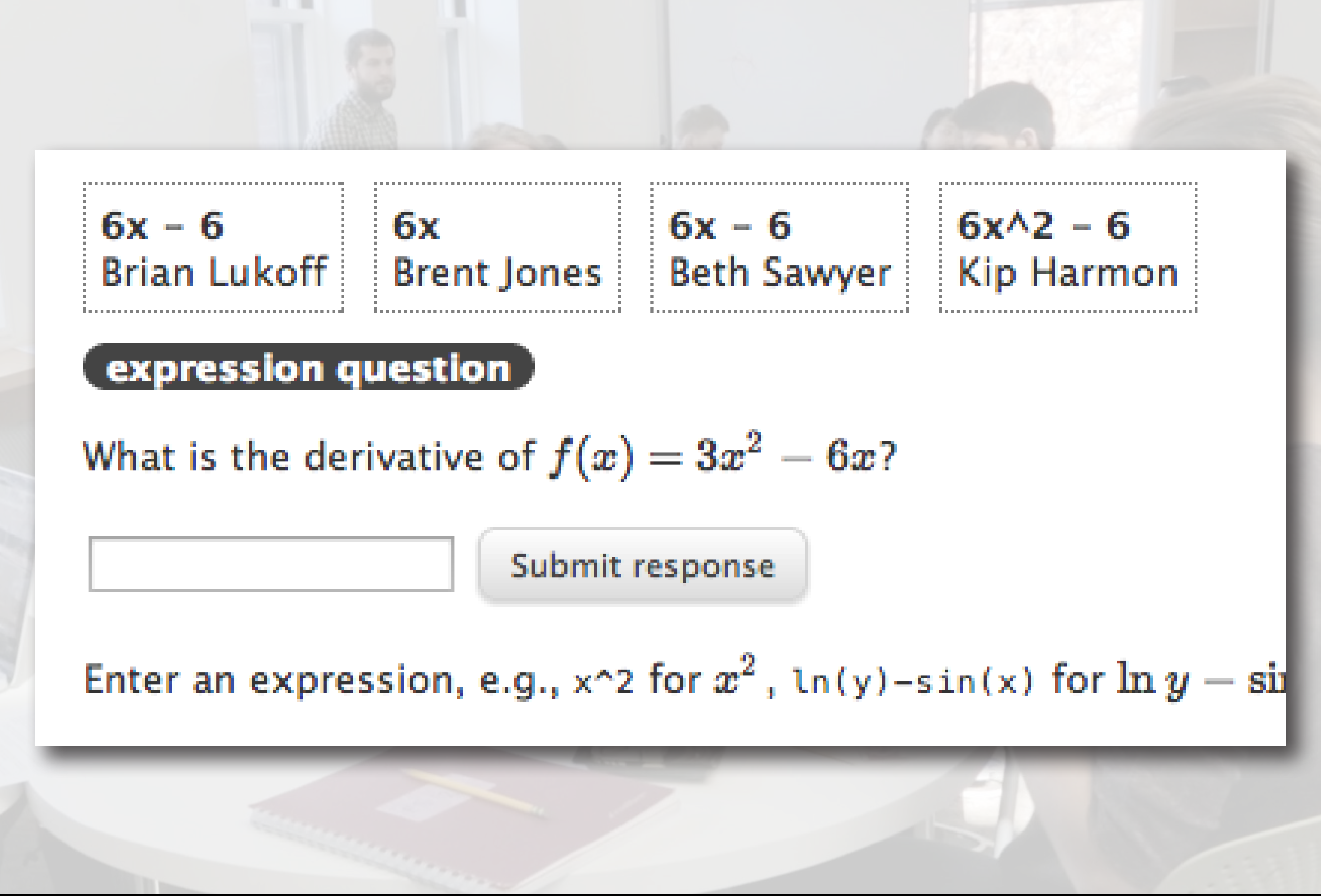
1 design

2 approach



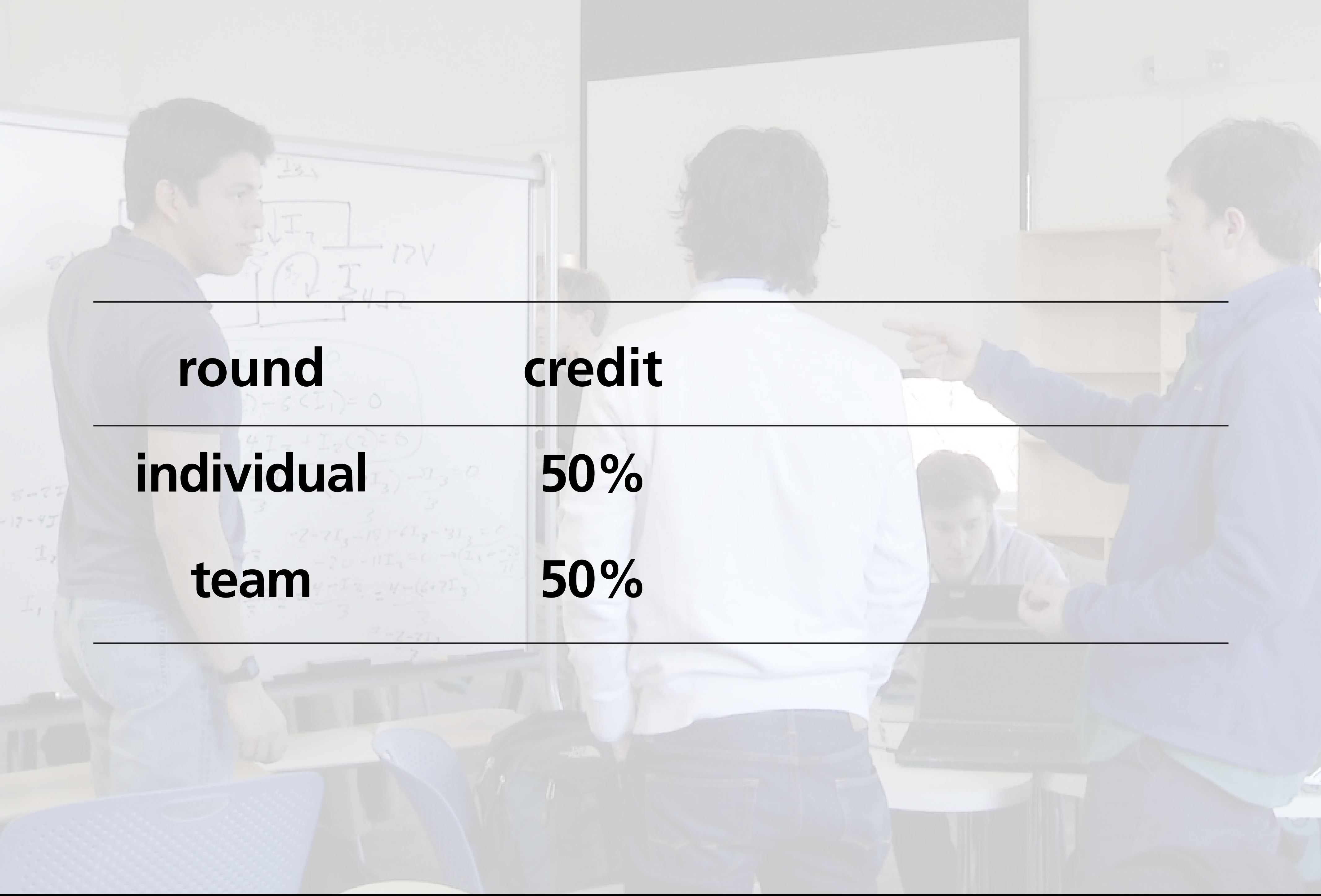
1 design

2 approach

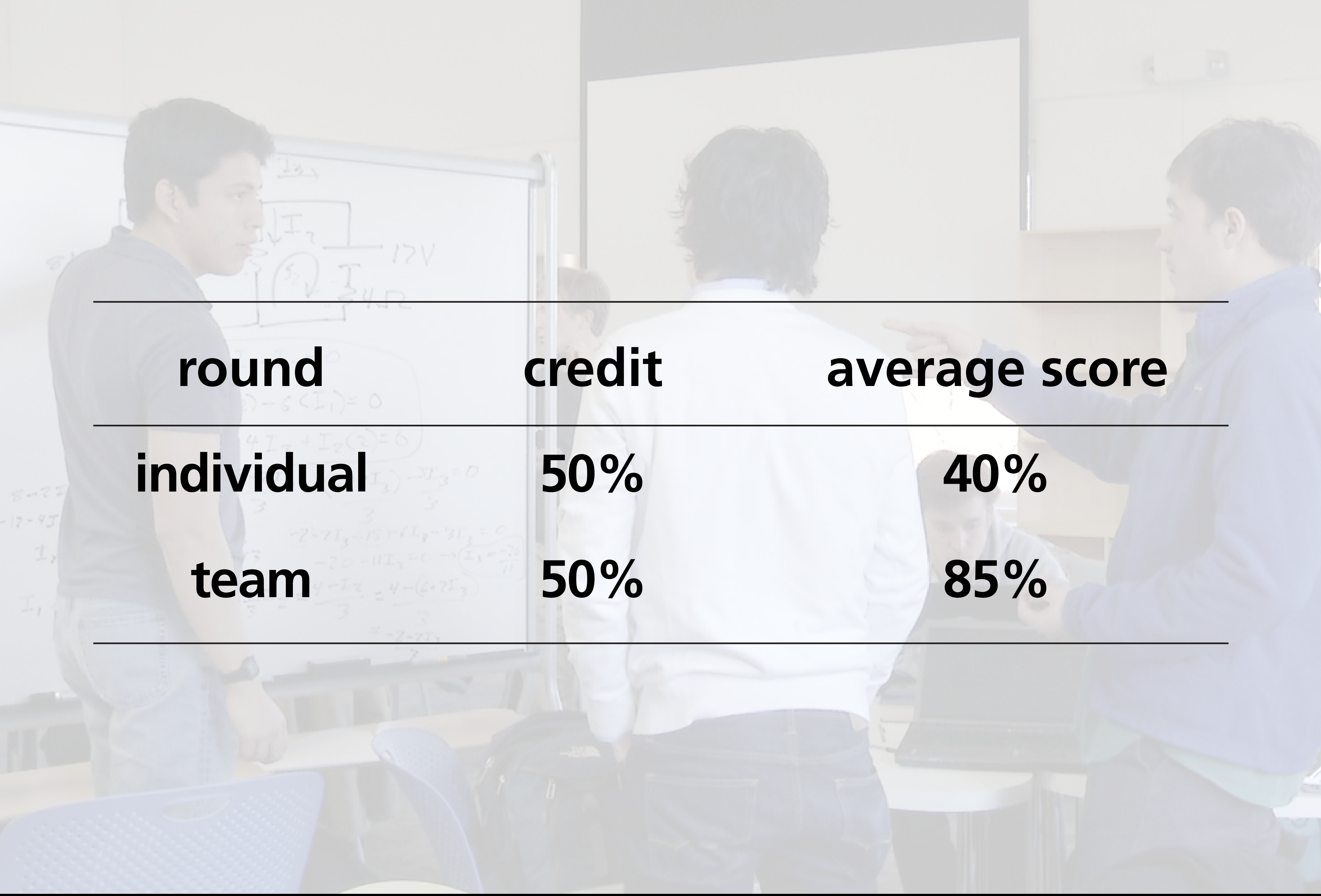


1 design

2 approach



round	credit
individual	50%
team	50%



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

Self, Peer, and Team assessment

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 t**ake 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

1 design

2 approach

Team, Peer, and Self assessment

4. Relative contributions

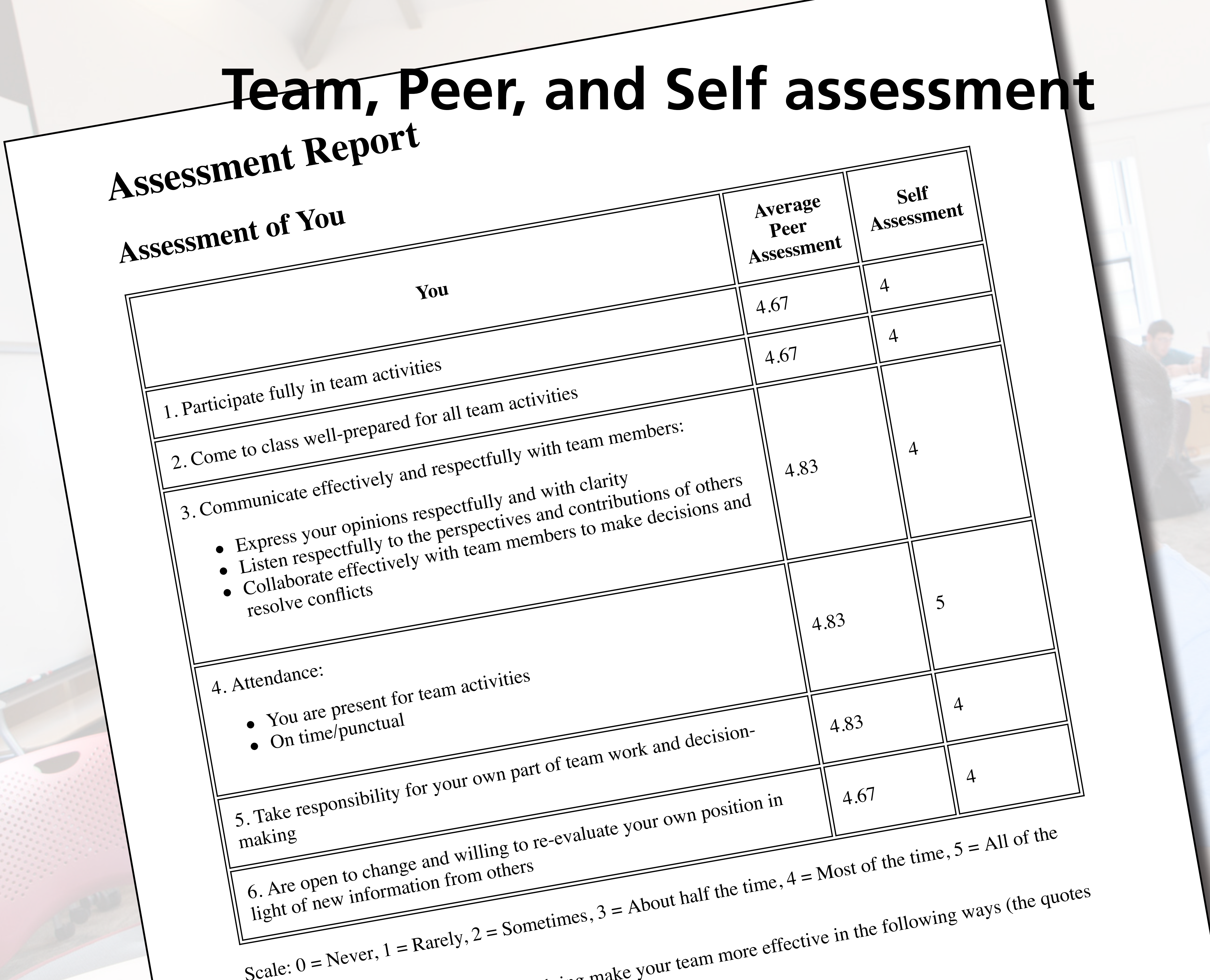
How much did each team member contribute to the overall goals? Please note that the **sum of all relative contributions must be zero** — if one person did more than his/her fair share, then others must have done less.

	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							

1 design

2 approach

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**

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

"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

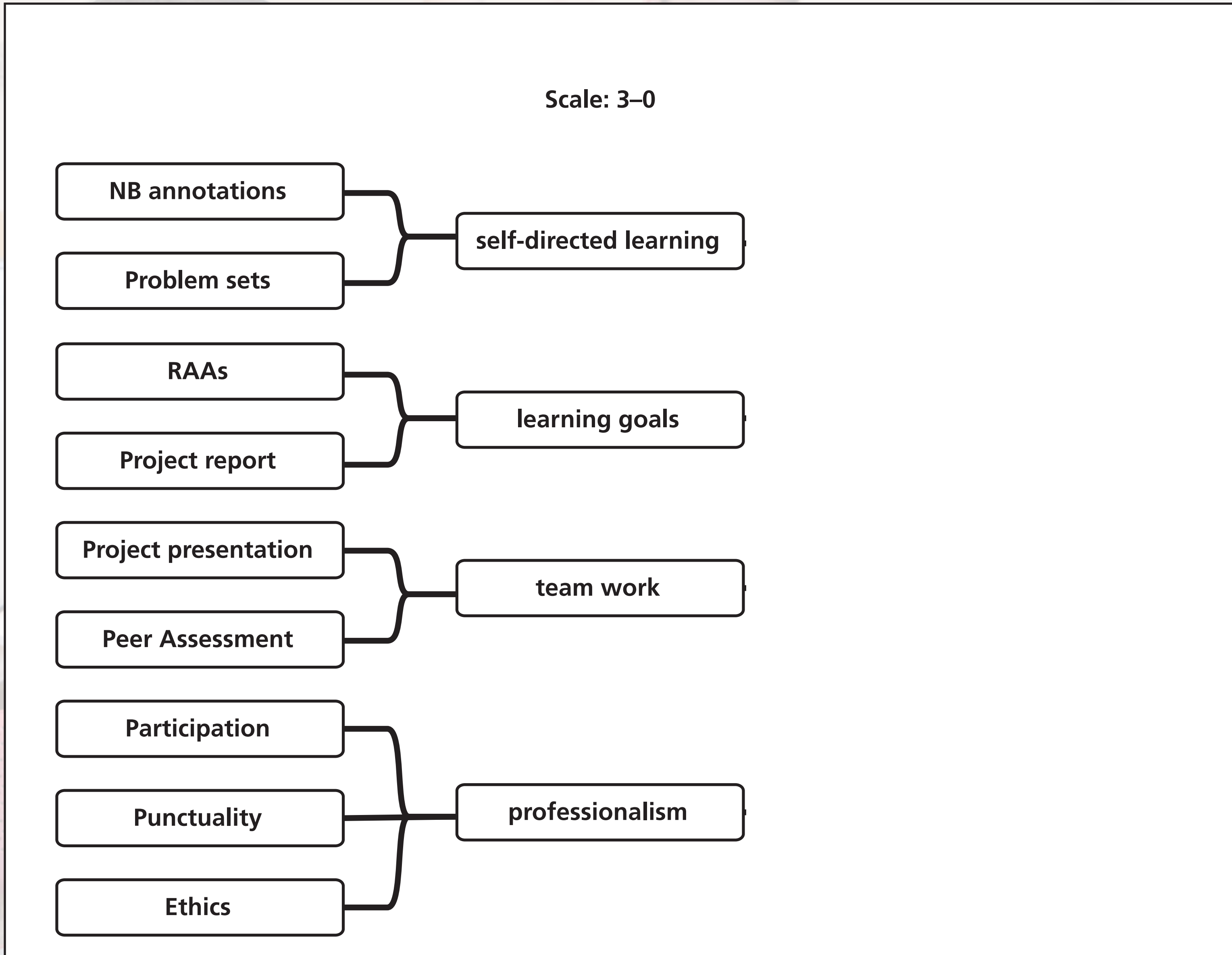
self-directed learning

learning goals

team work

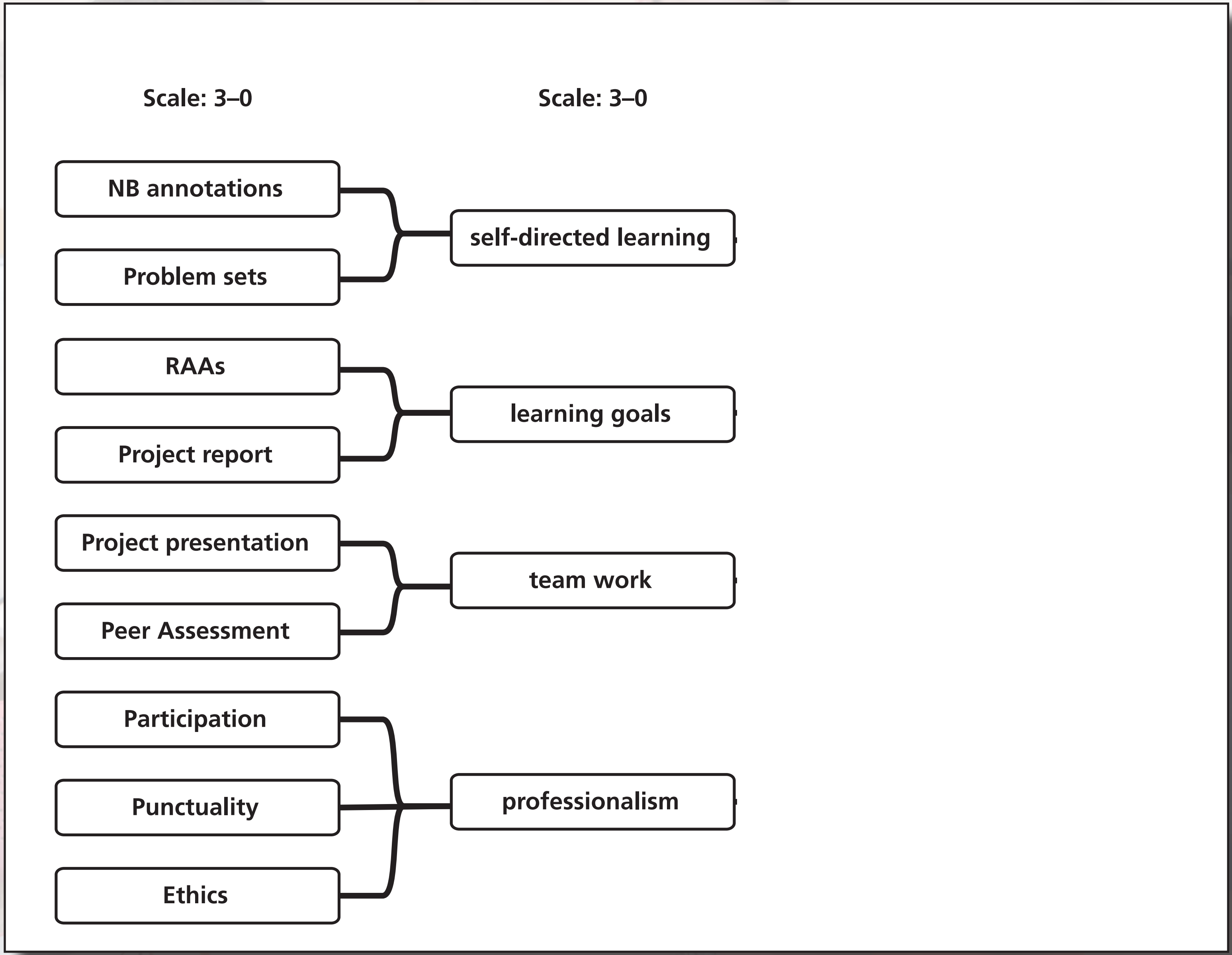
professionalism

Assessment



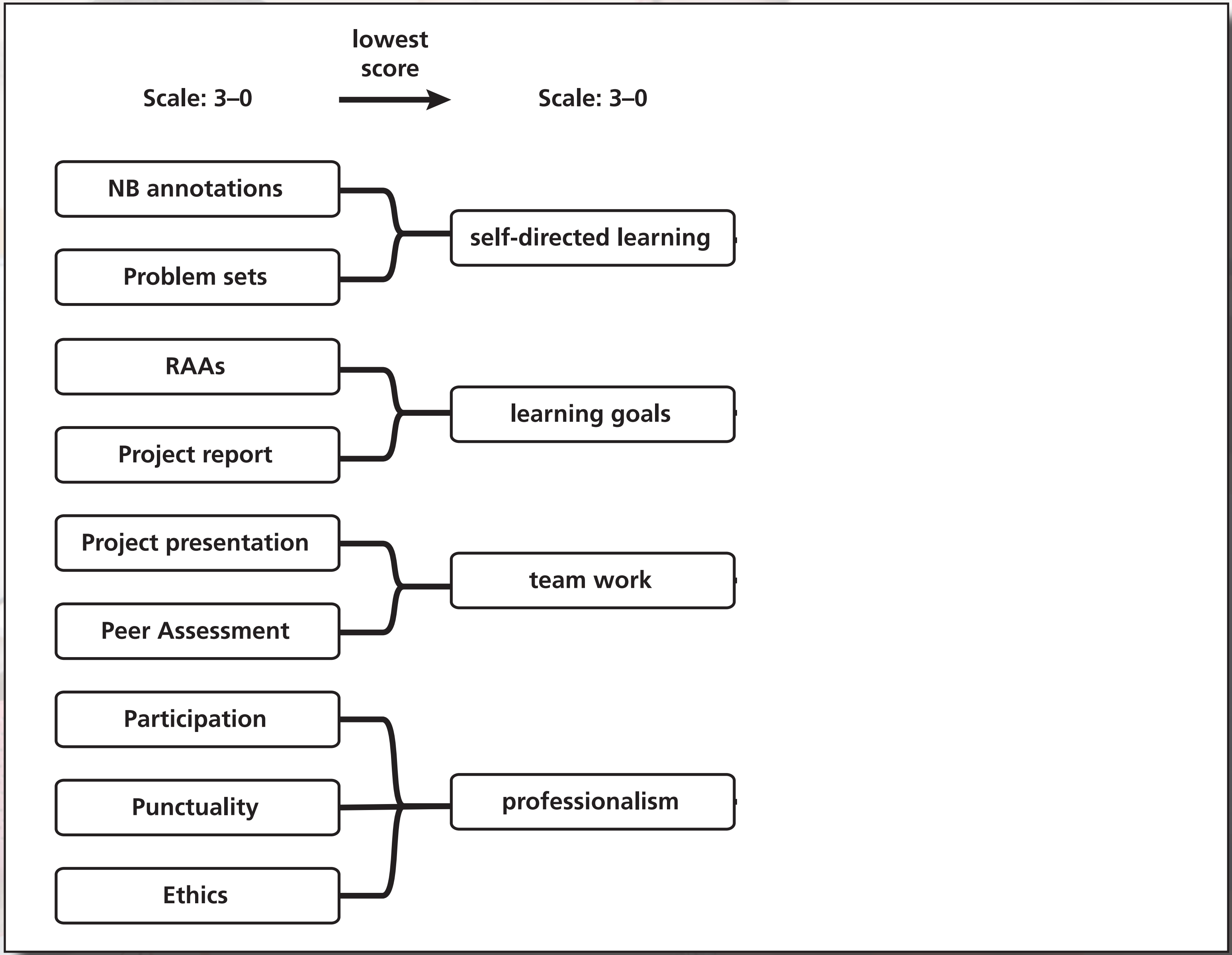
1 design 2 approach

Assessment



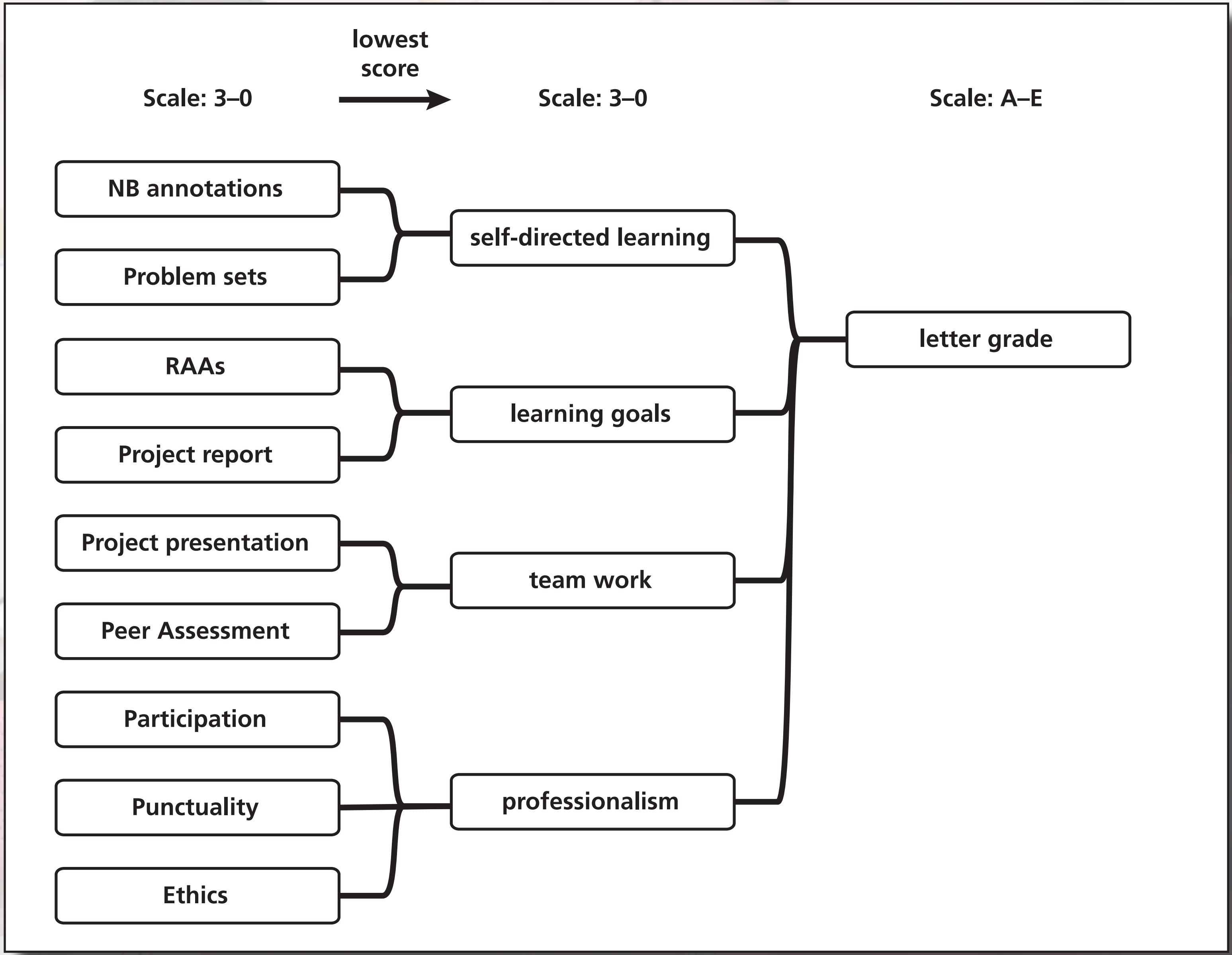
1 design 2 approach

Assessment



1 design   2 approach

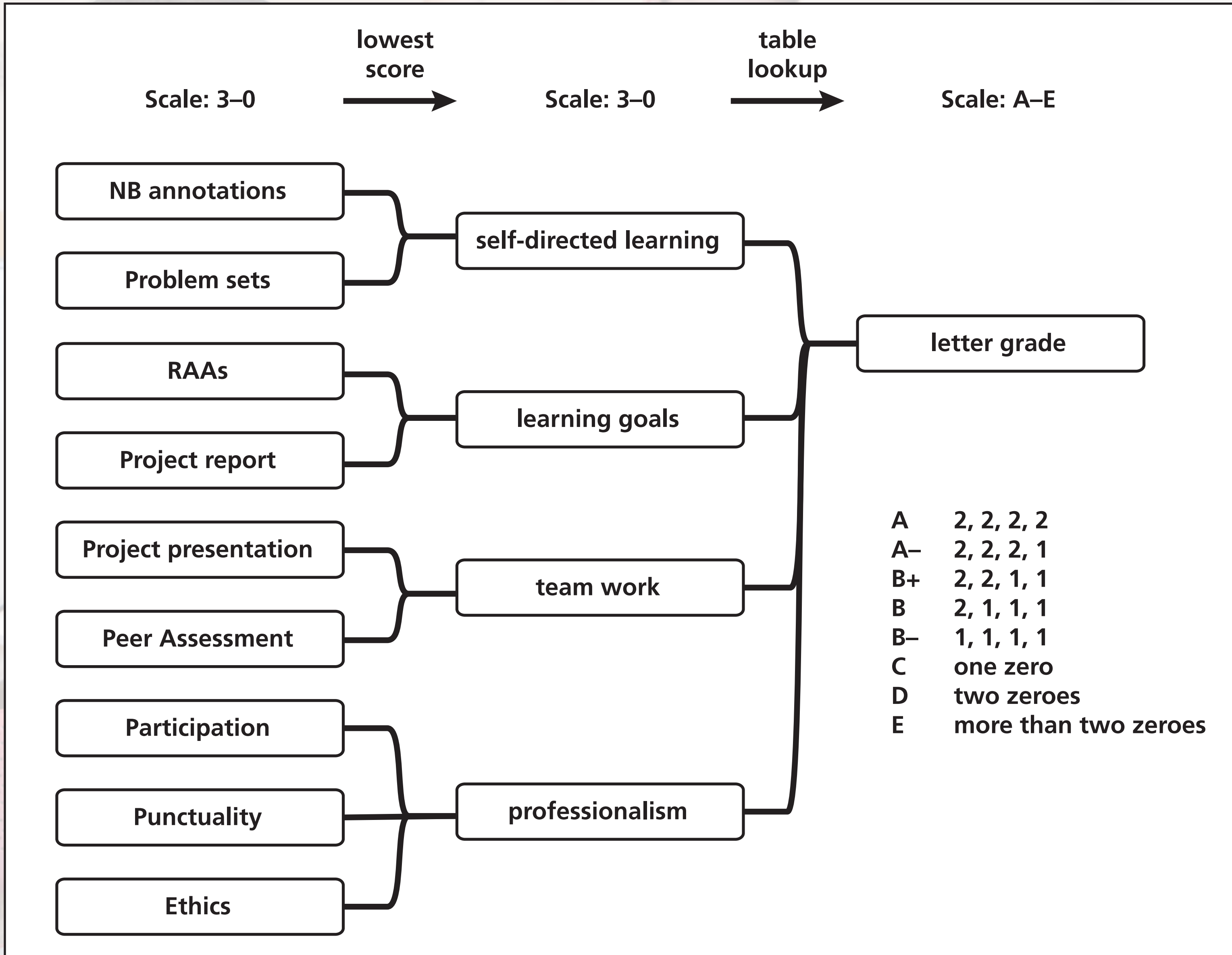
Assessment



1 design

2 approach

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

1 design
2 approach
3 results

Ownership

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."

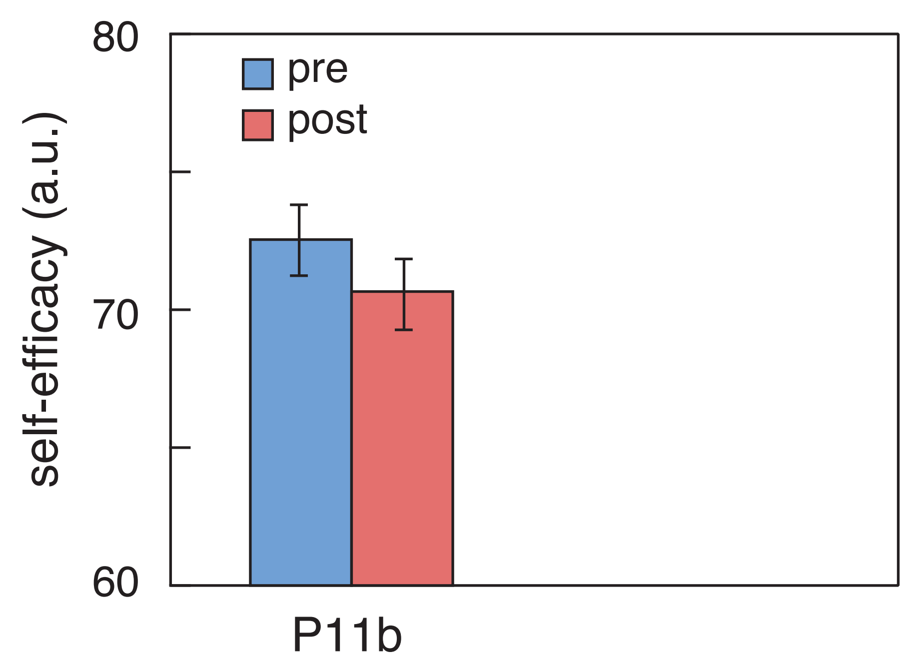
(via email)

Self-efficacy

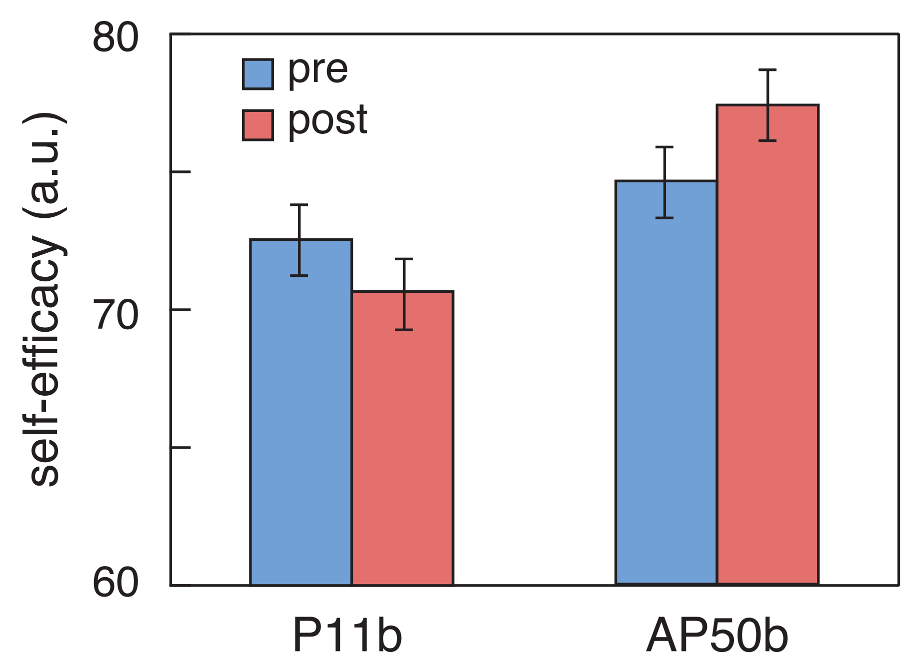
Self-efficacy

(students' belief in their ability to succeed)

Self-efficacy



Self-efficacy



1 design
2 approach
3 results

Self-directed learning

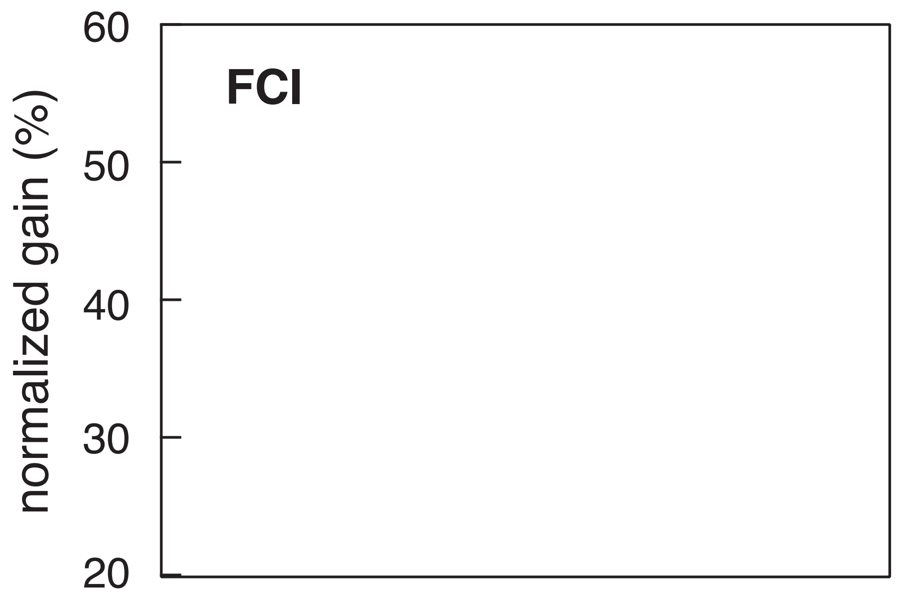
1 design 2 approach 3 results

Self-directed learning

NB data shows:

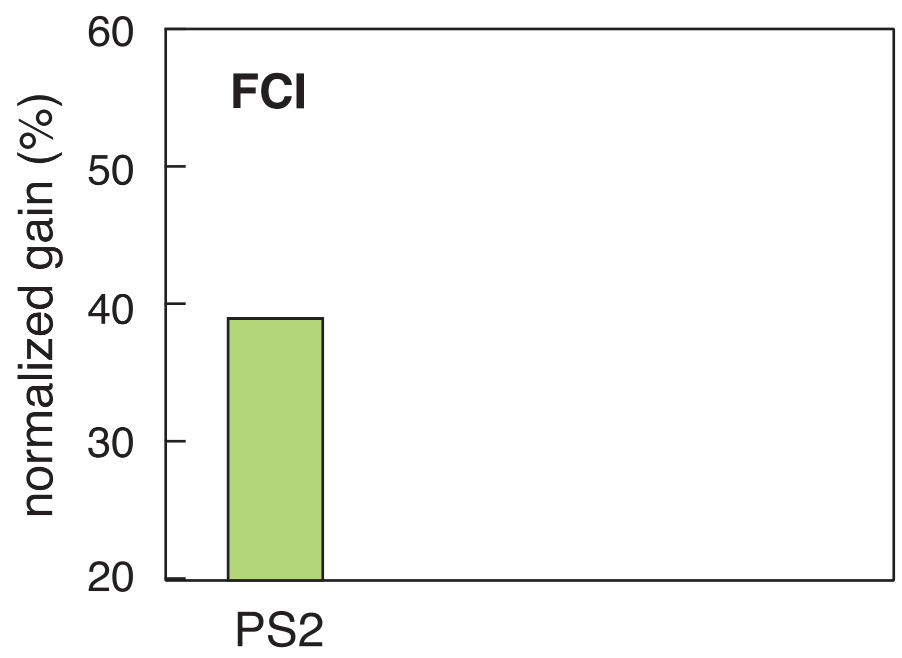
- student spend on average 2.3 hrs/chapter
- 600–700 annotations/chapter (8–10/stu)

Conceptual Mastery



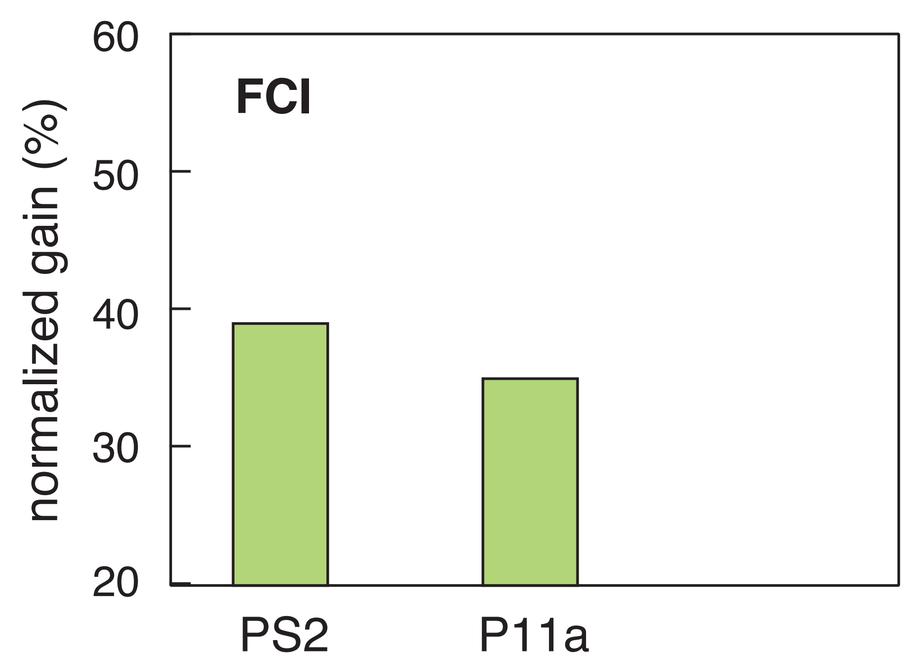
1 design 2 approach 3 results

Conceptual Mastery

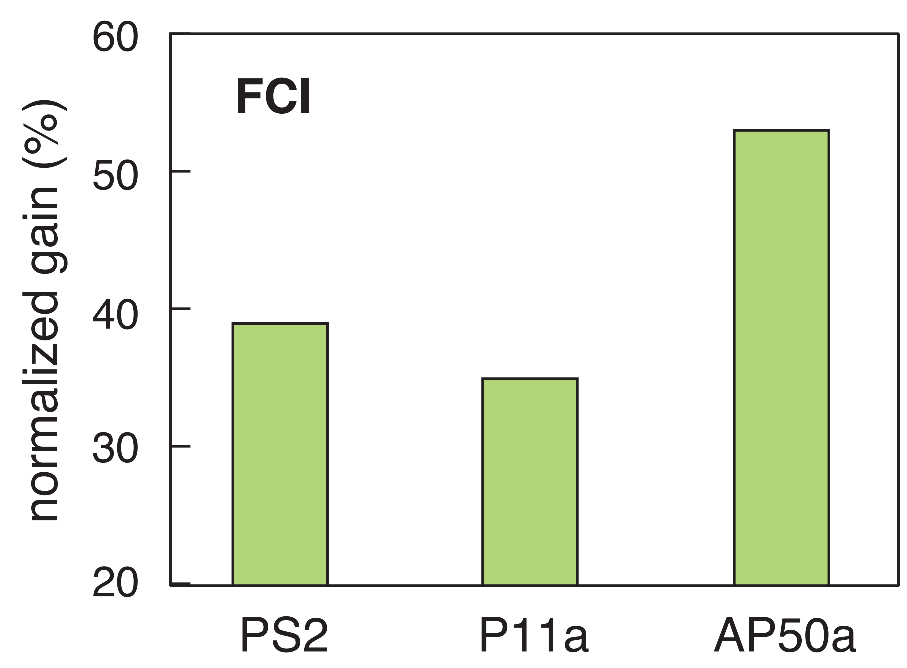


1 design
2 approach
3 results

Conceptual Mastery

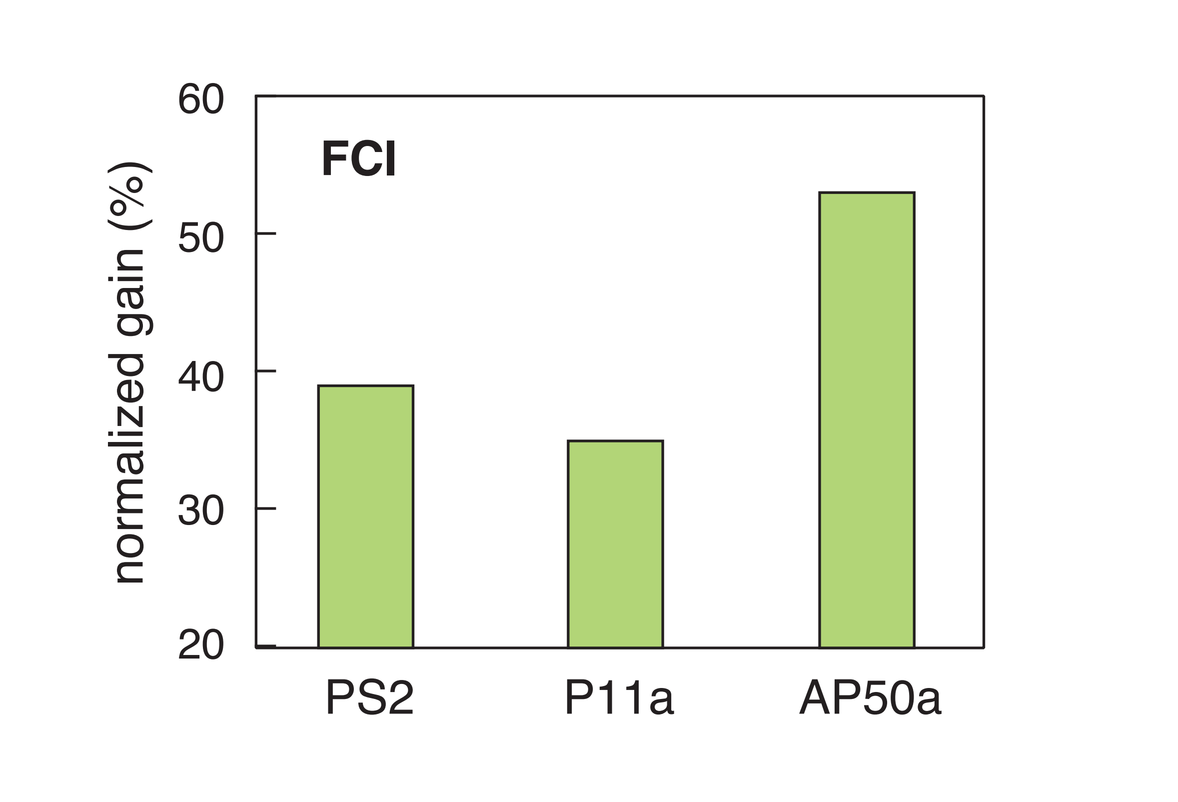


Conceptual Mastery



1 design 2 approach 3 results

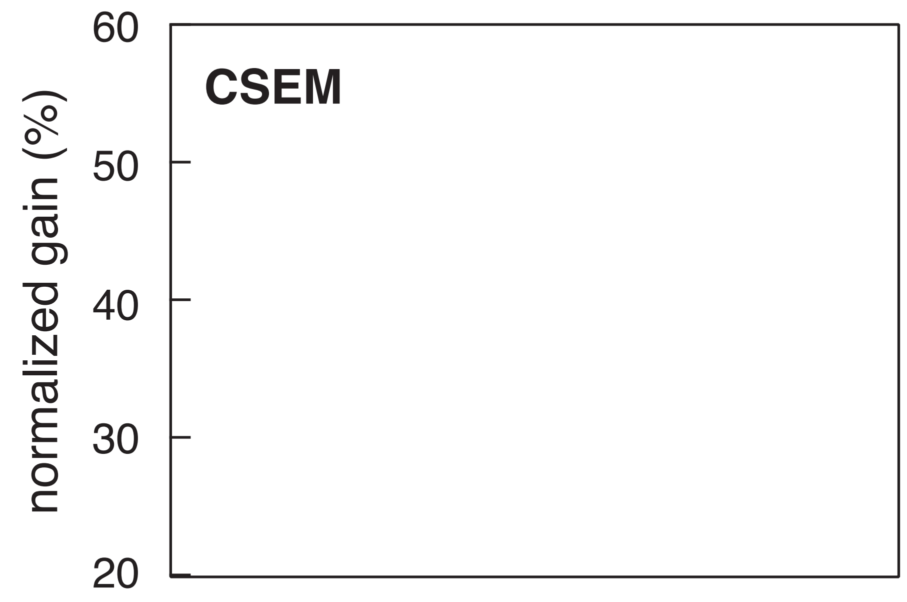
Conceptual Mastery



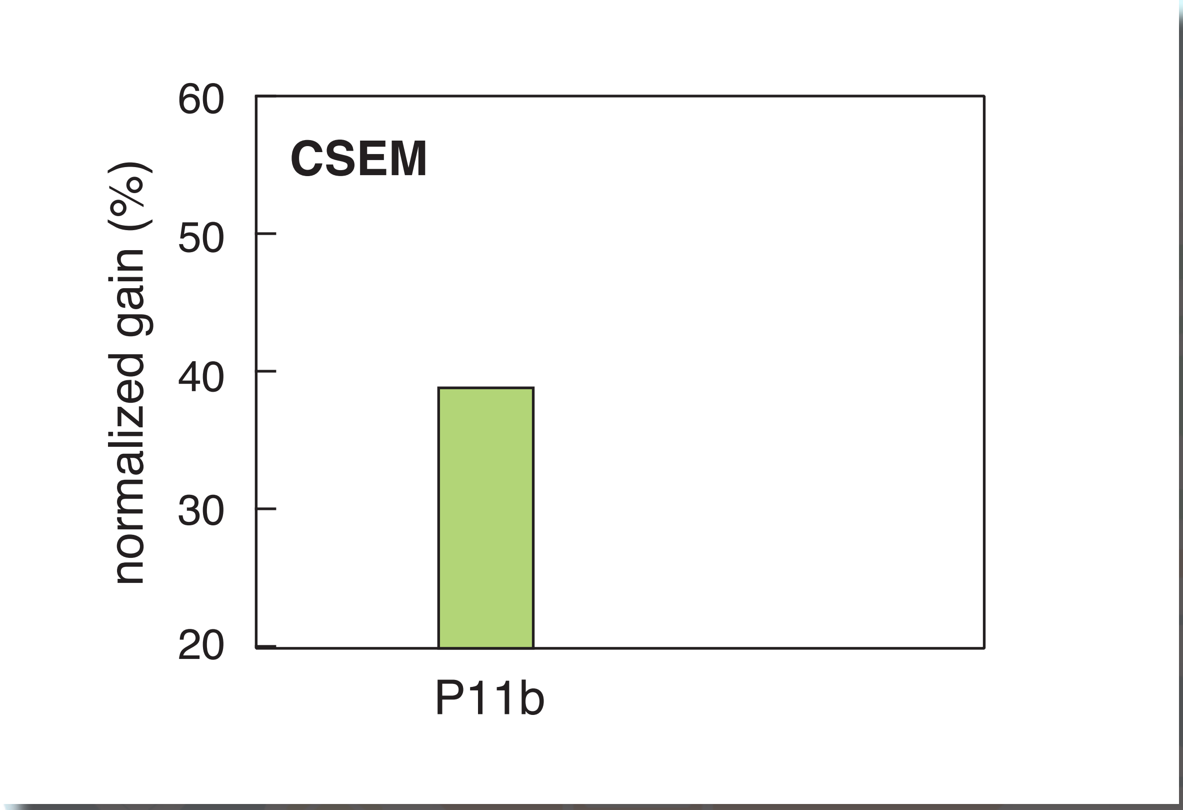
largest conceptual gain in *any* course past 6 yrs!

1 design **2 approach** **3 results**

Conceptual Mastery

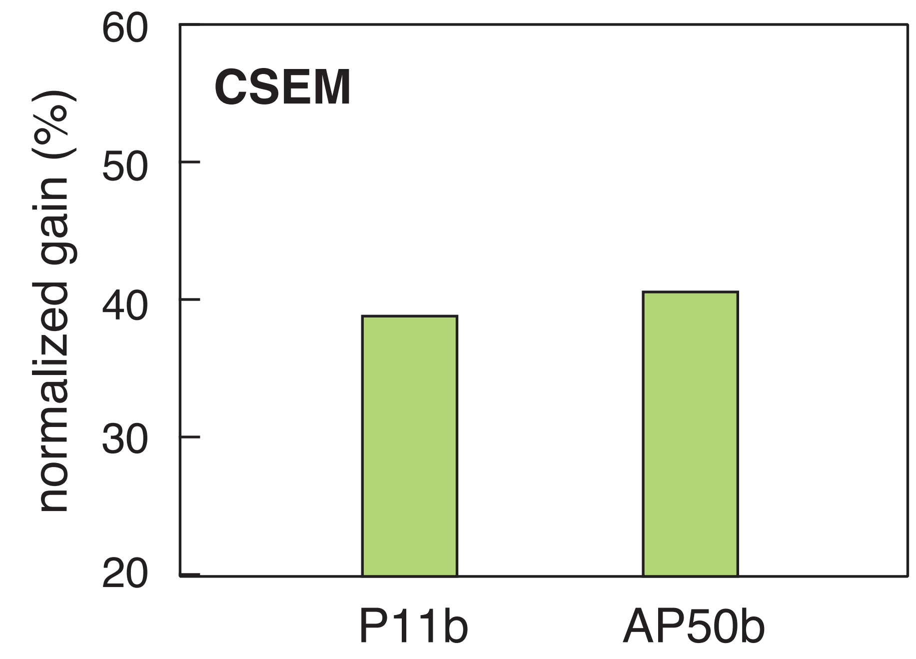


Conceptual Mastery



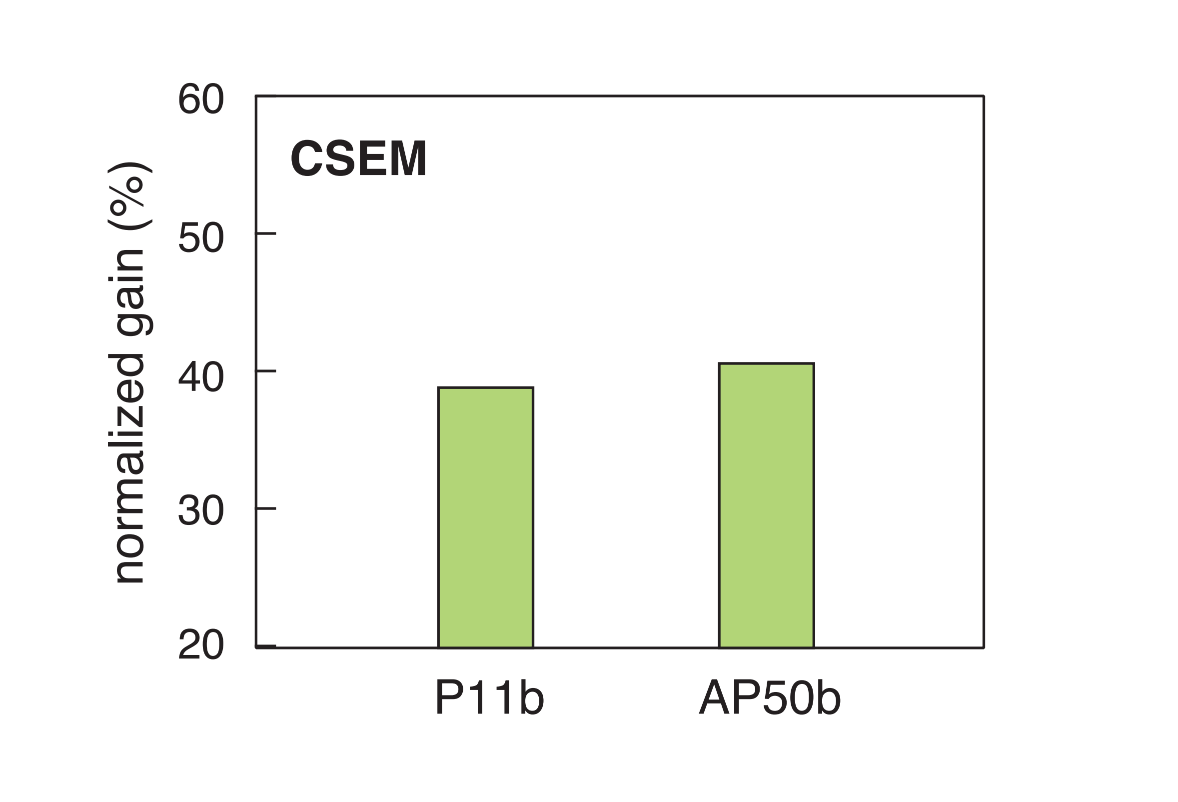
1 design   2 approach   3 results

Conceptual Mastery



1 design **2** approach **3** results

Conceptual Mastery



as good as when I do my best teaching!

1 design

2 approach

3 results

Can create ownership of learning physics!

fun!

Can create ownership of learning physics!

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

1 design **2 approach** **3 results**

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