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Flat space, deep learning

Universiteit Groningen
Groningen, Netherlands, 26 November 2015

Flat space, deep learning

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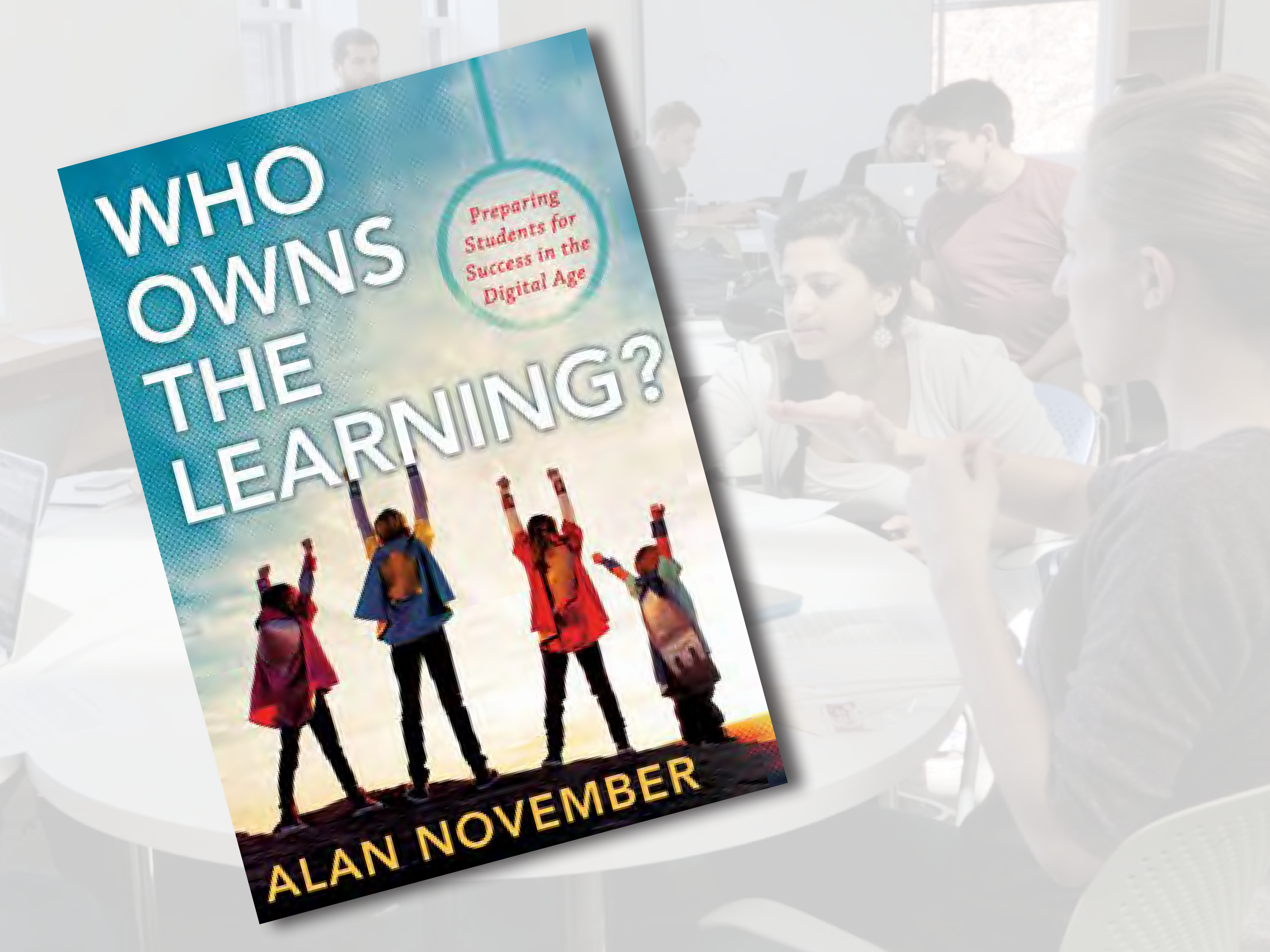
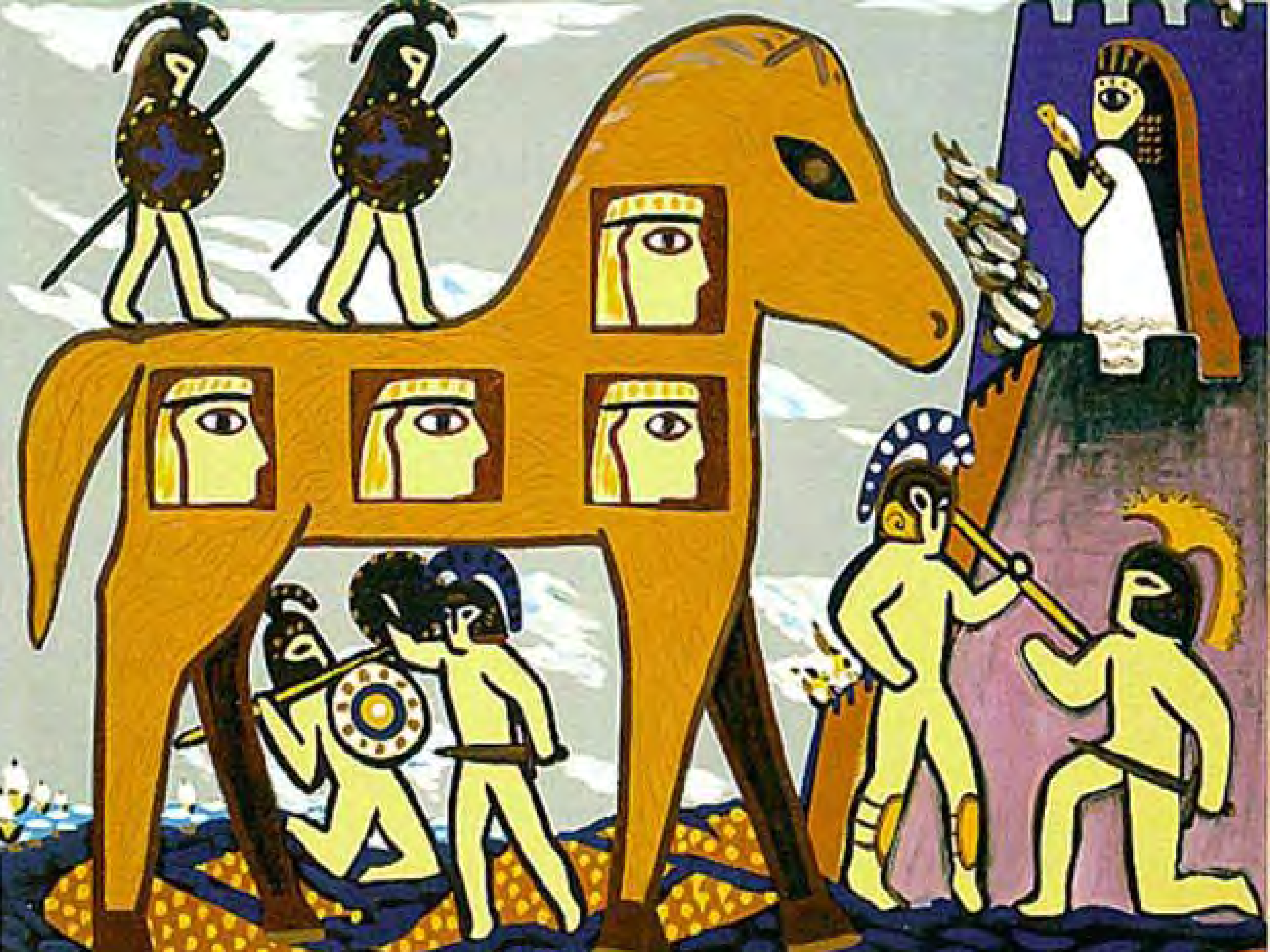


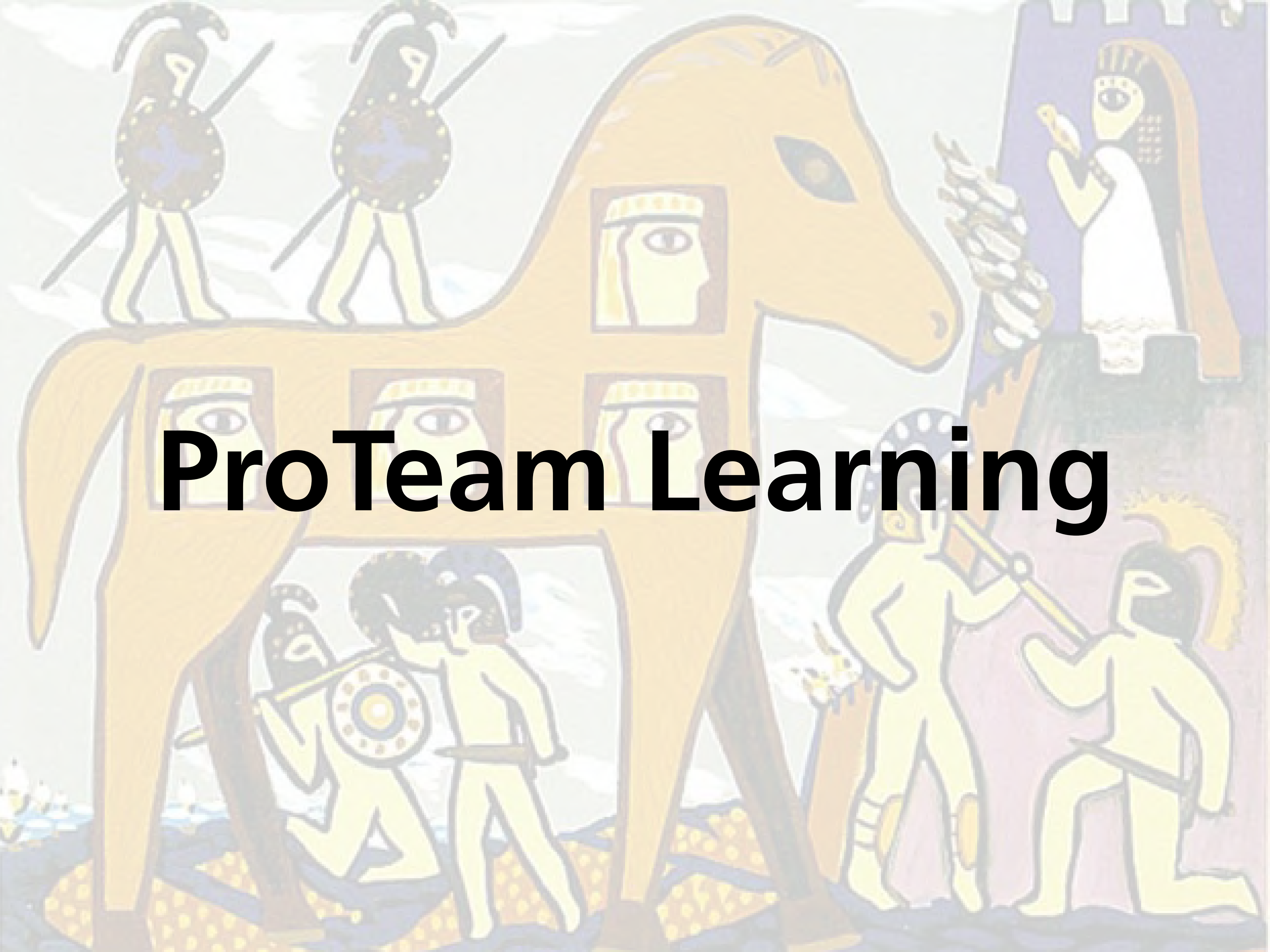
WHO OWNS THE LEARNING?
Preparing Students for Success in the Digital Age
ALAN NOVEMBER

Ownership of learning *physics*?




team & project-based approach

ProTeam Learning

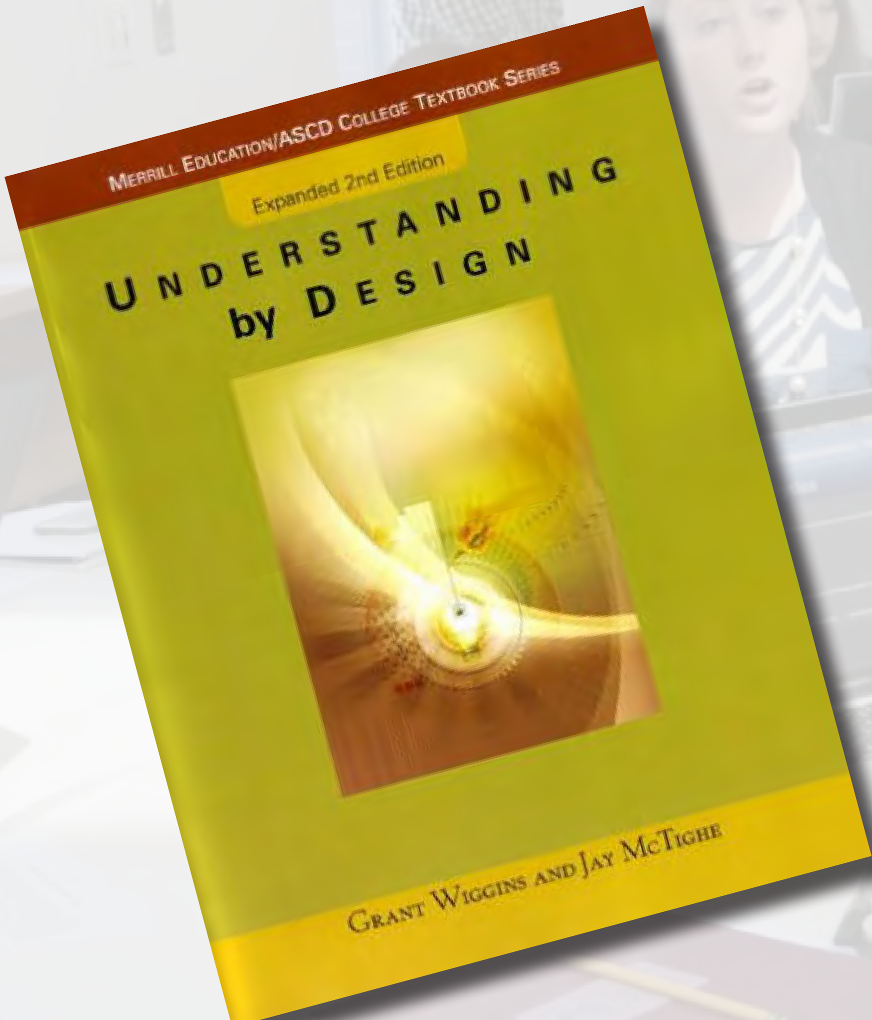


1 design

❶ design ❷ approach

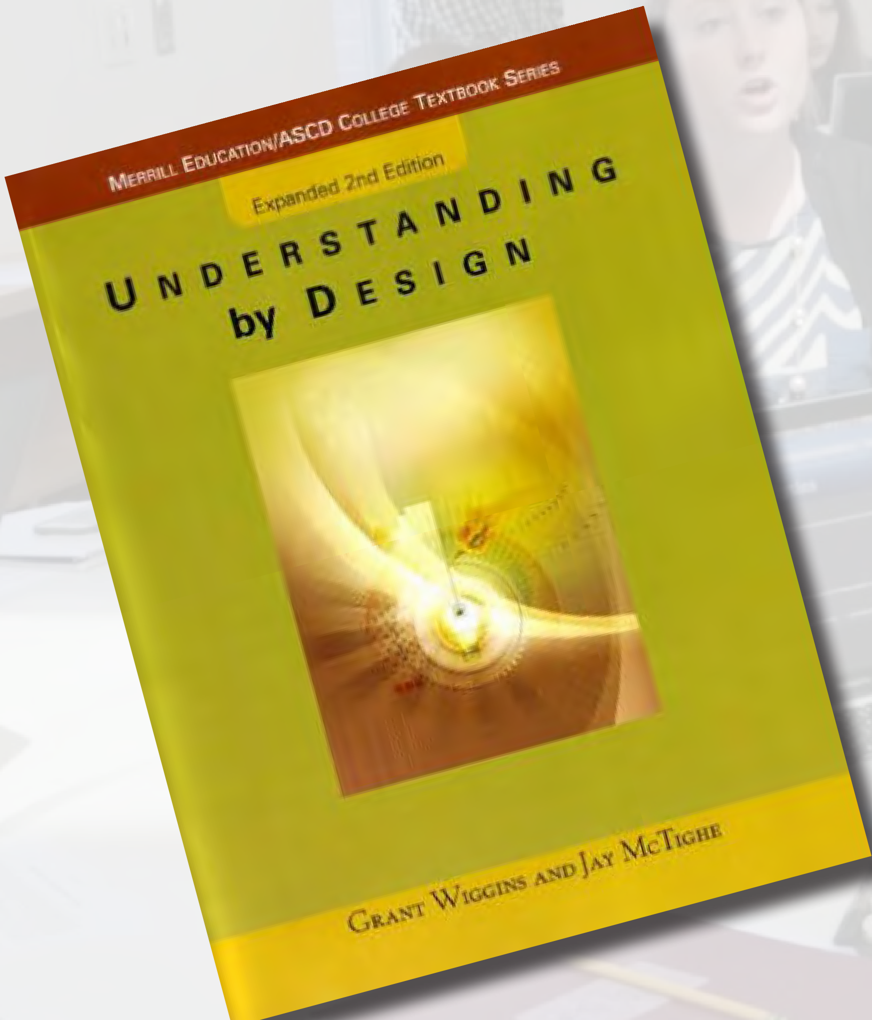
1 design 2 approach 3 results

Setting learning goals



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

Backward design

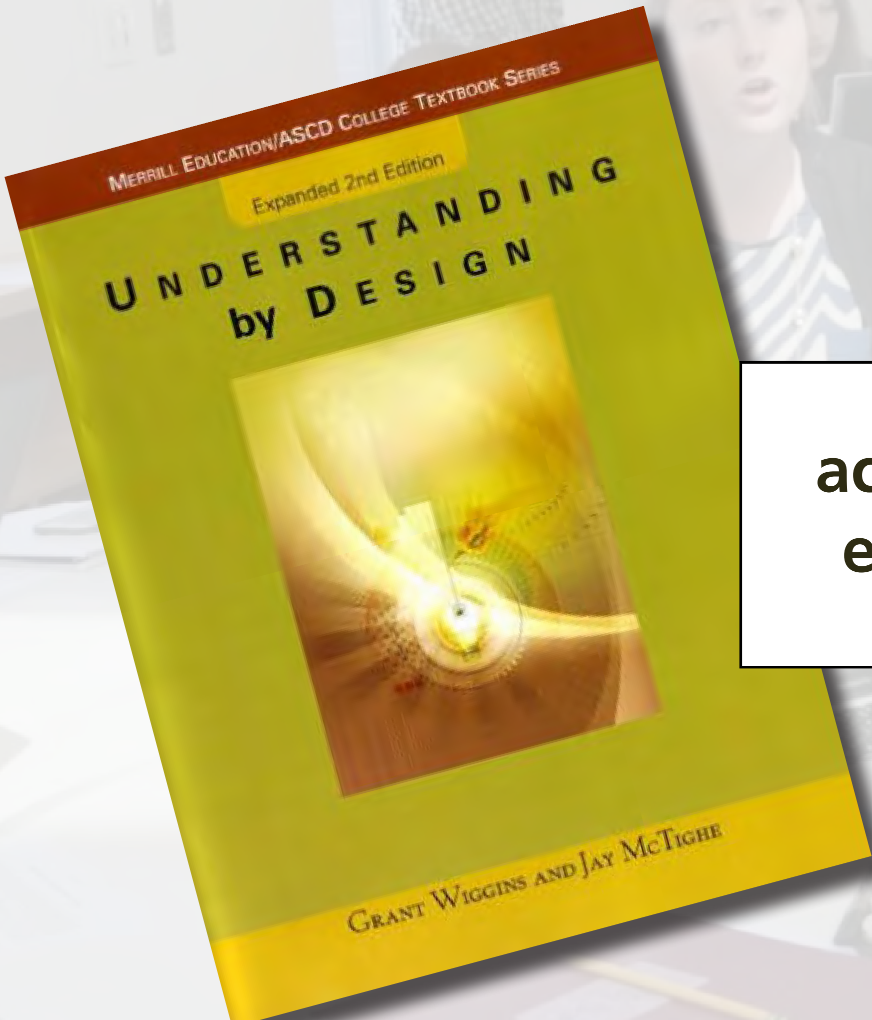


desired outcomes

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

1 design

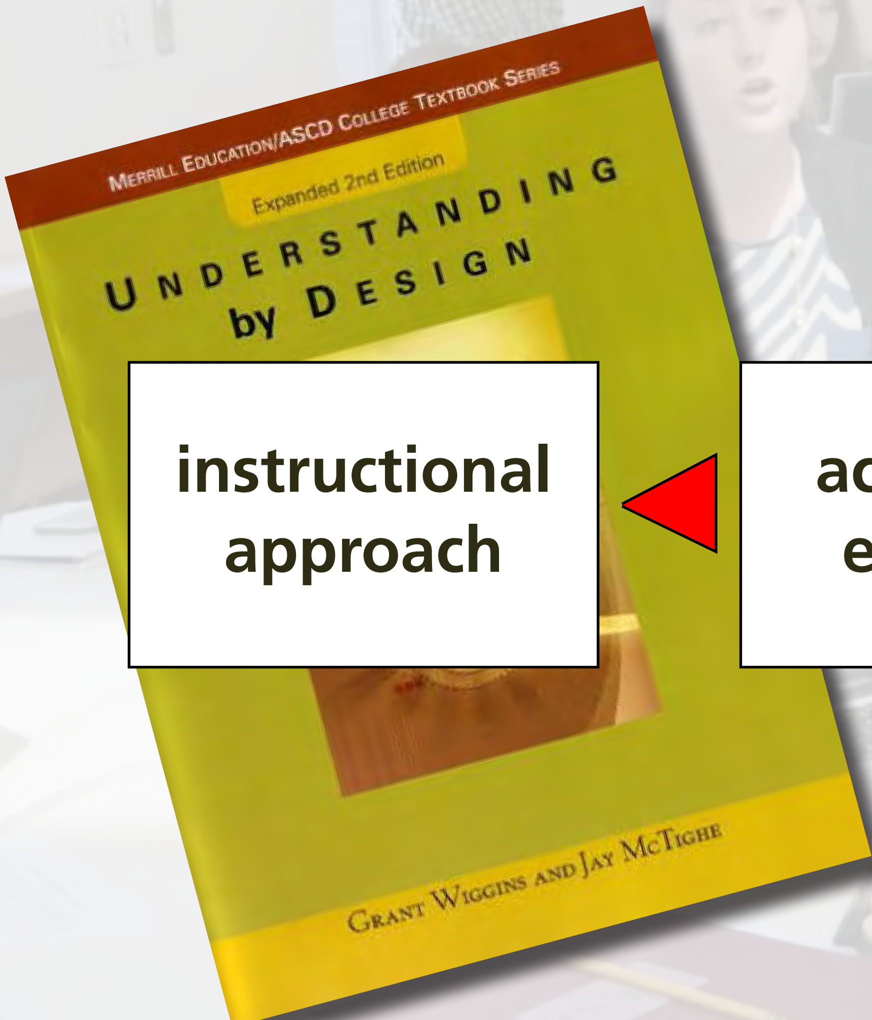
Backward design



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
- [illegible] knowledge of physics to solve problems
  [illegible] interpreting them

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

1 design

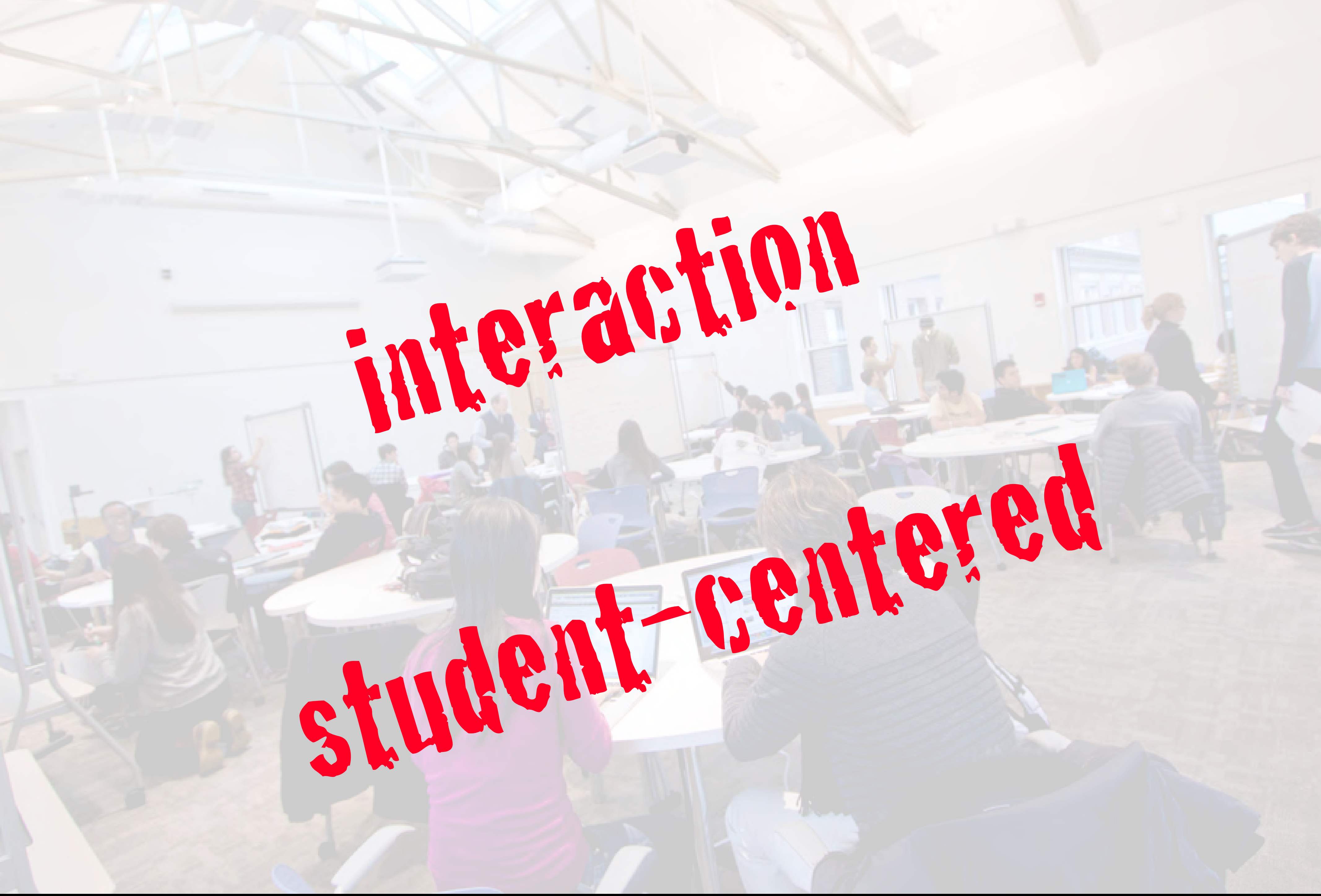
content-specific goals

http://bit.ly/ap50visitor

1 design


information transfer
faculty-centered

1 design



1 design

1 design

2 approach

1 design

2 approach

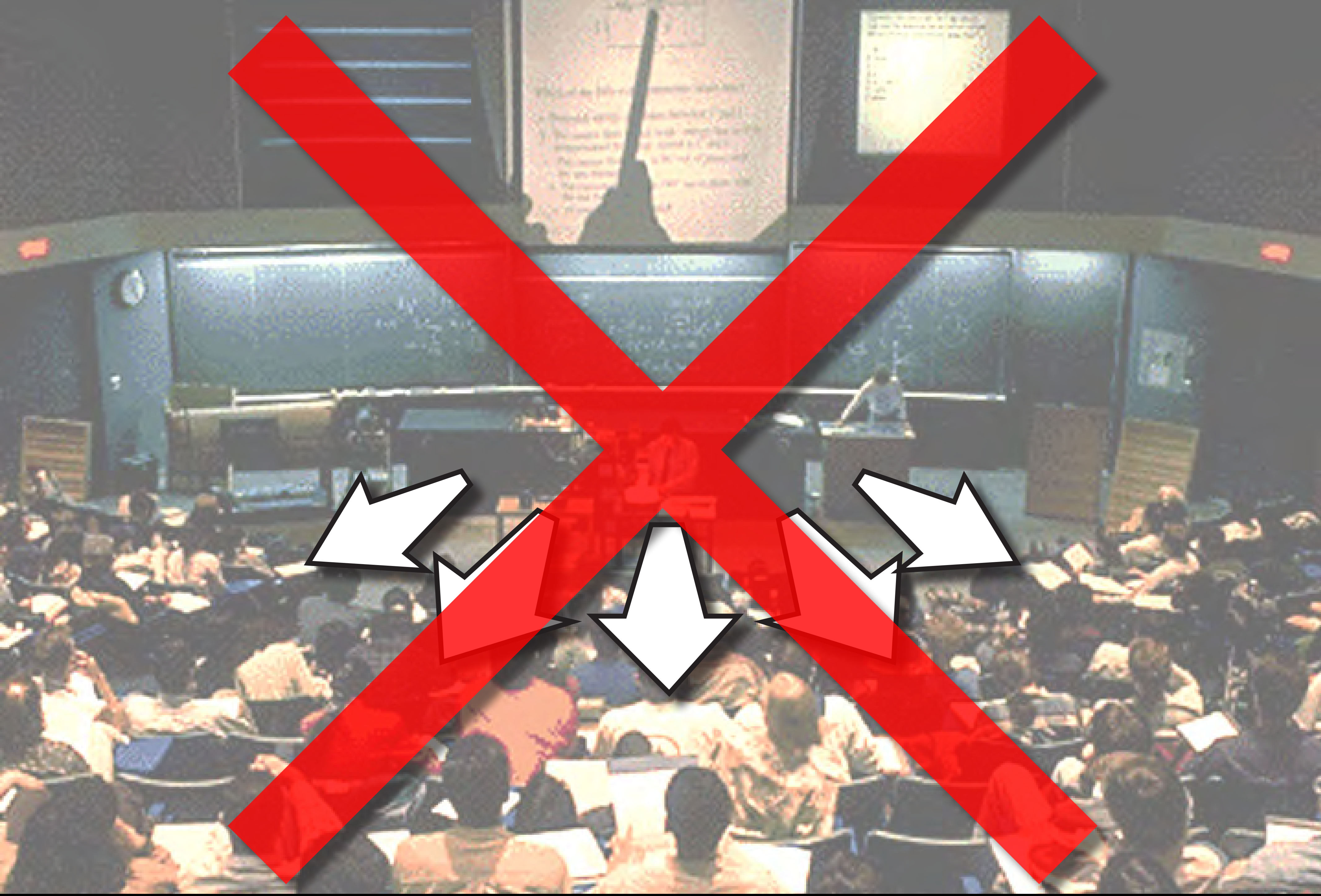

CLASS
ROOM
1st exposure
deeper understanding
ROOM
CLASS
1st exposure
deeper understanding

1 design

2 approach

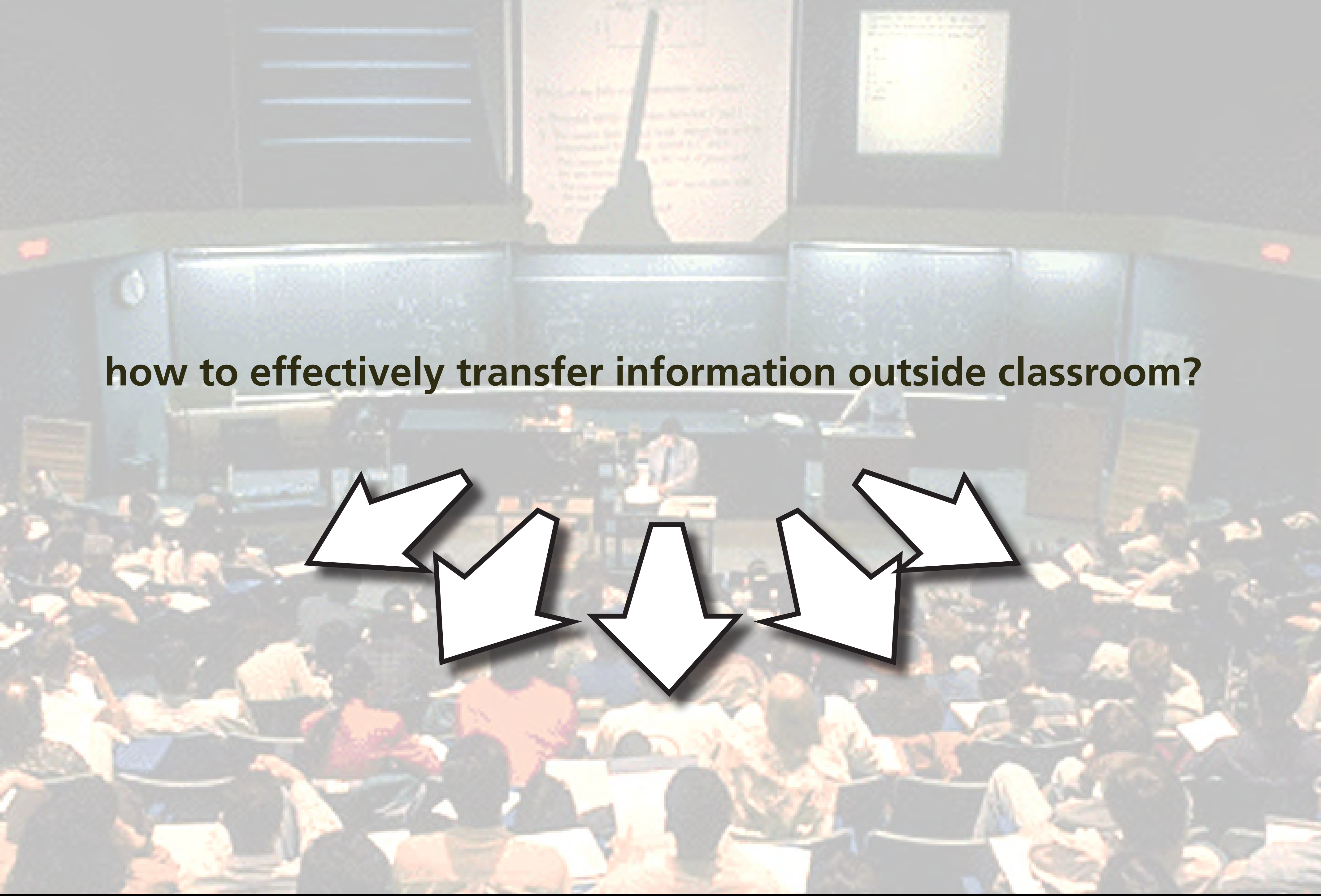
Three major components:

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



1 design

2 approach



how to effectively transfer information outside classroom?

1 design **2** approach

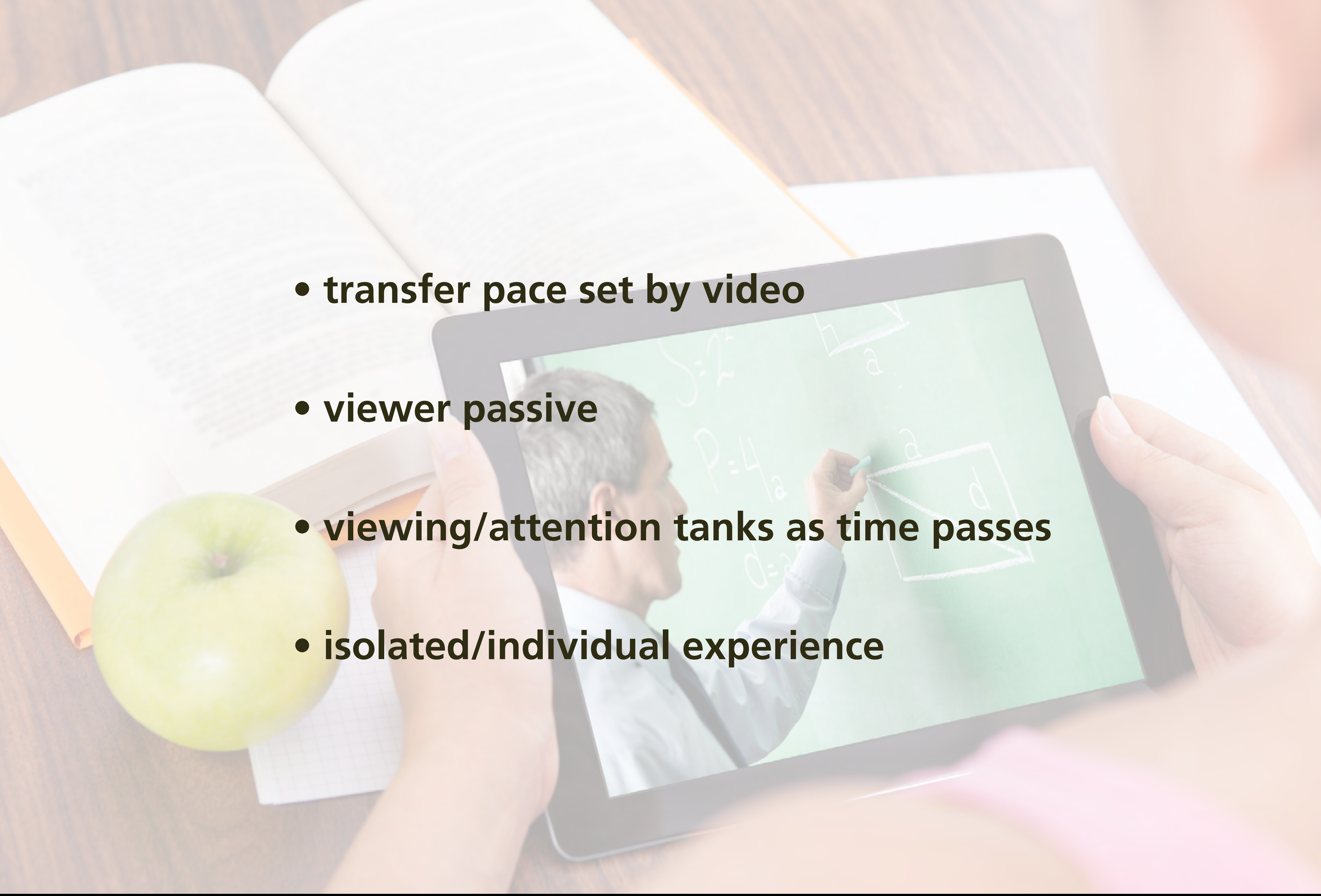
1 design

2 approach

but…

1 design

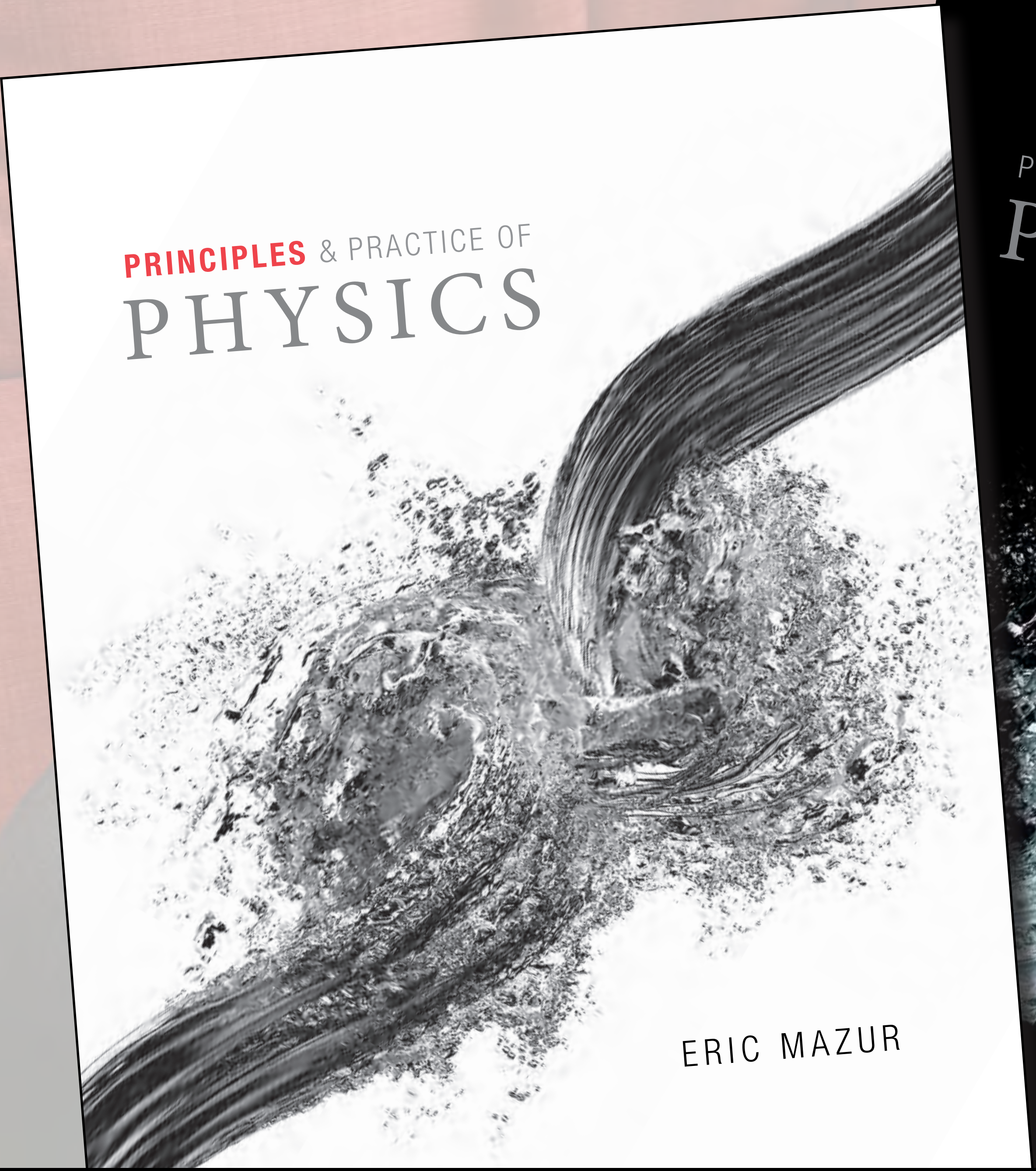
2 approach

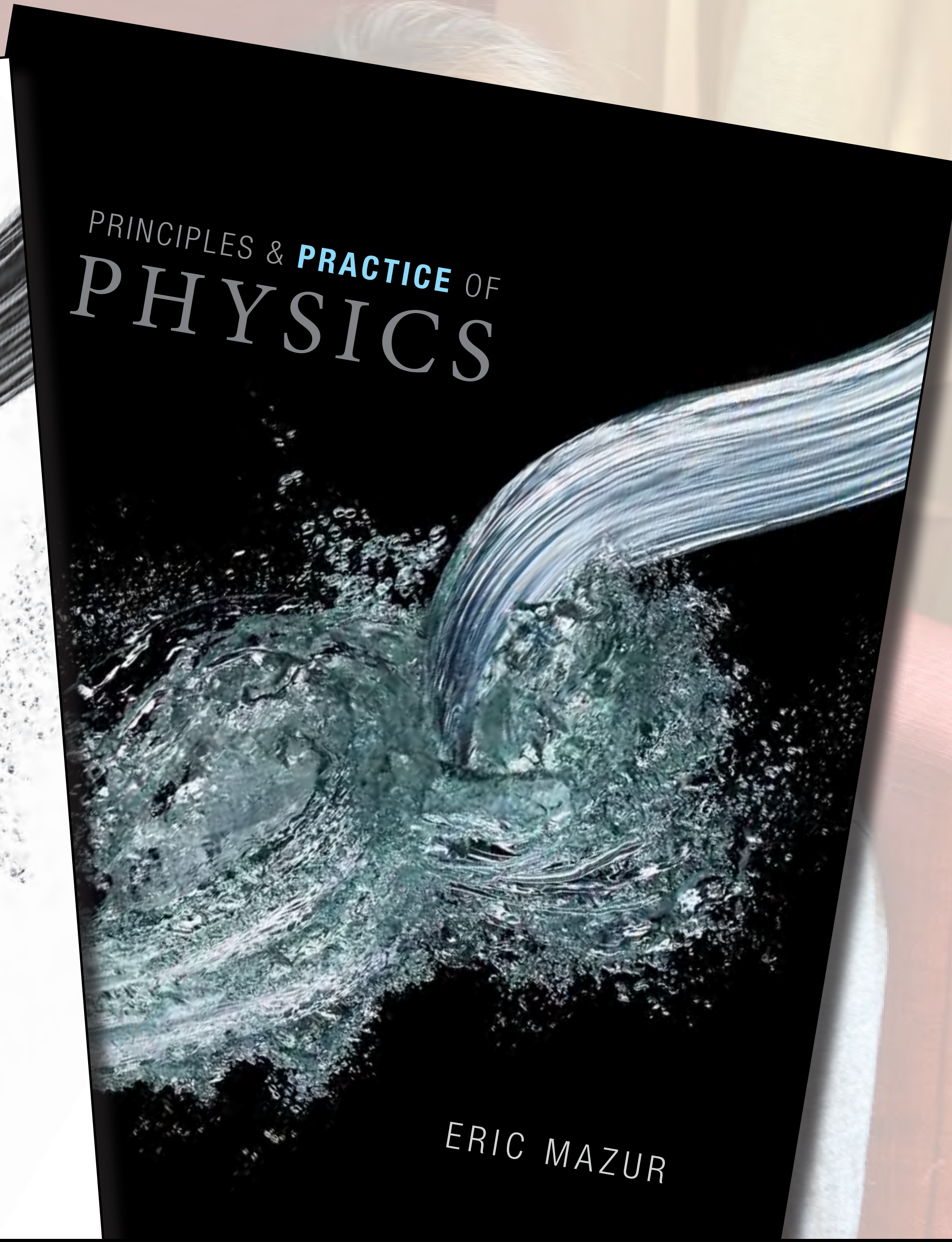


- transfer pace set by video
- viewer passive
- viewing/attention tanks as time passes
- isolated/individual experience


we’re simply moving this outside classroom!

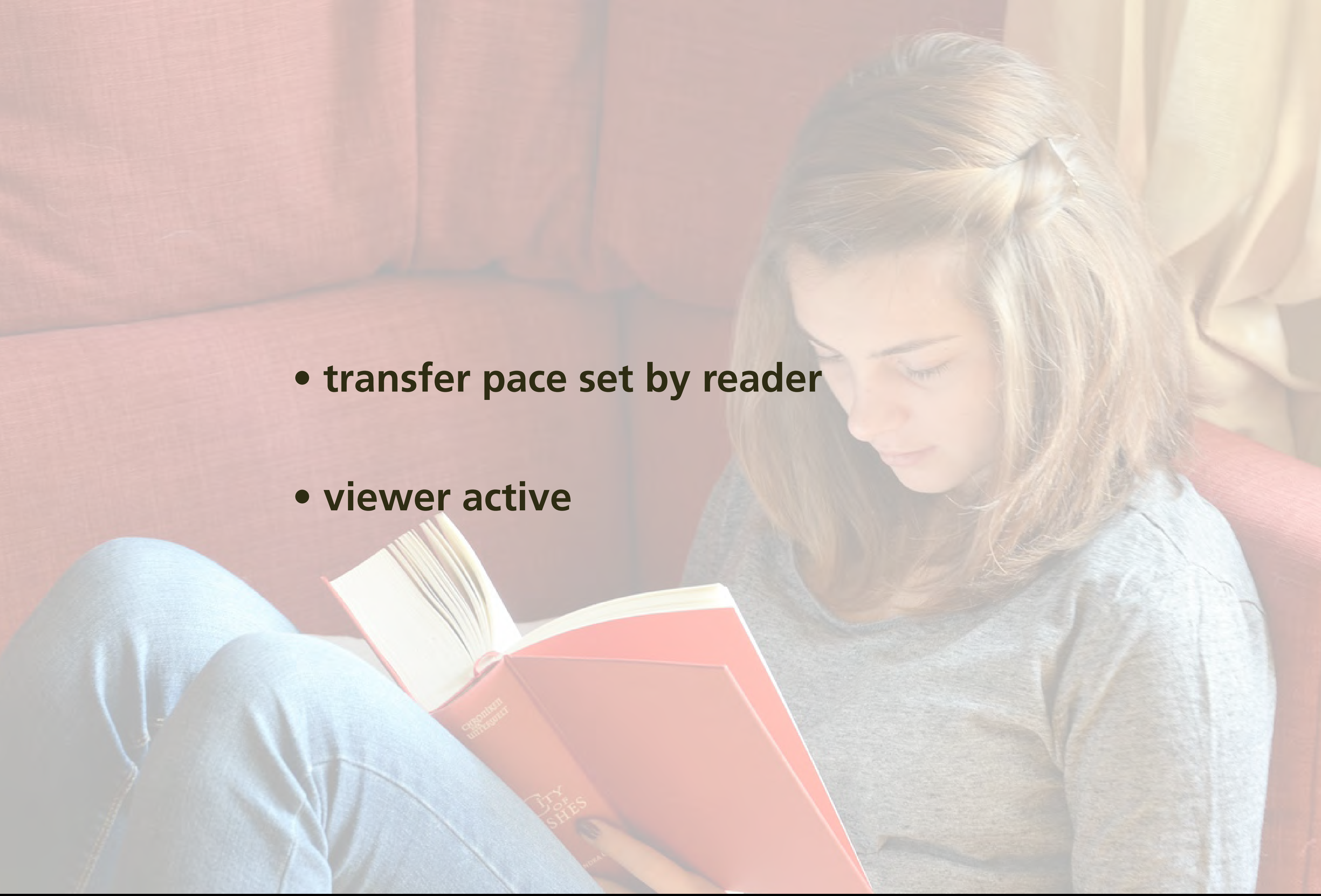
1 **design** 2 **approach**





1 design

2 approach



- transfer pace set by reader
- viewer active

1 design 2 approach

but…

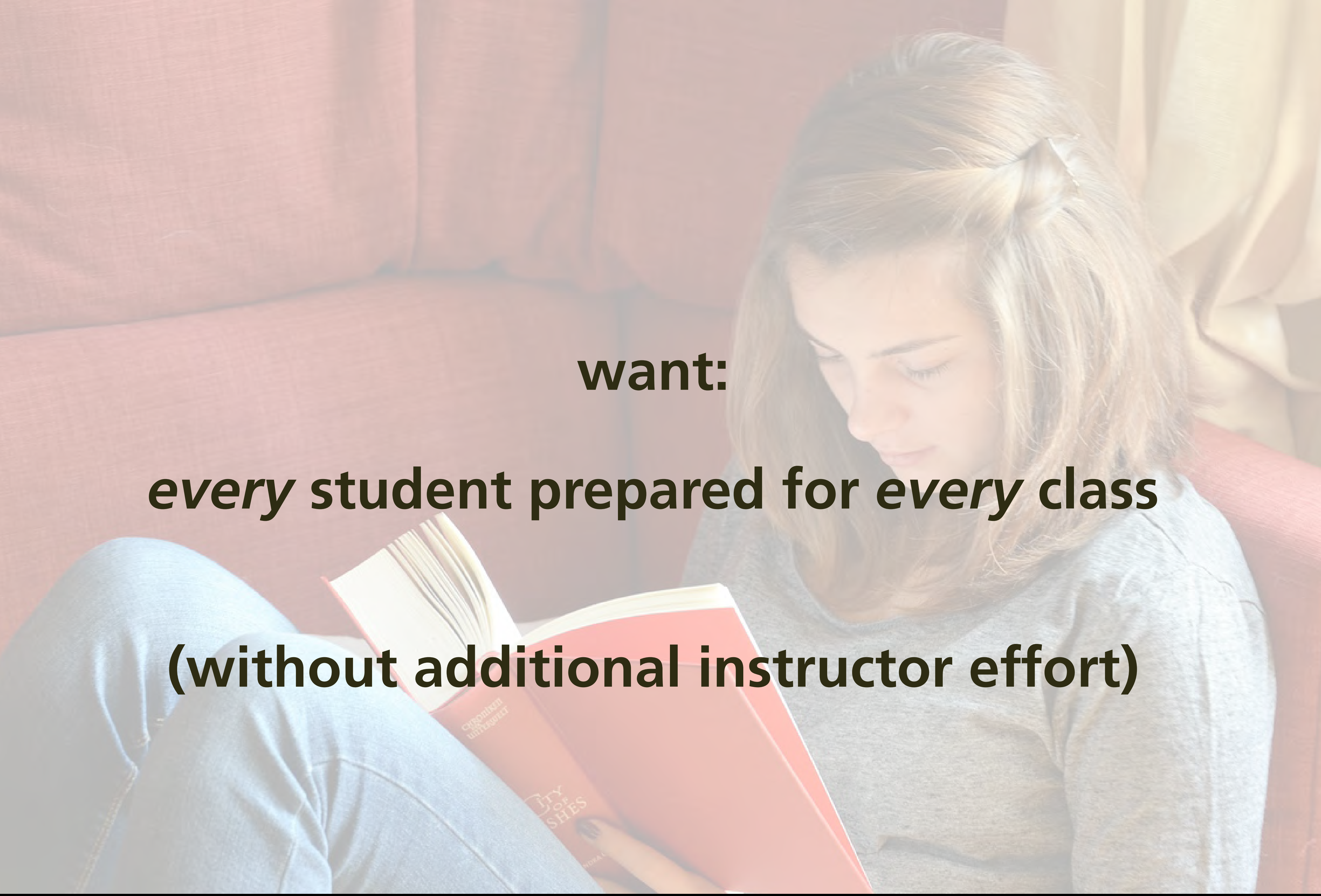
❶ design ❷ approach

1 design 2 approach

want:

***every* student prepared for *every* class**

1 design **2 approach**



want:

***every* student prepared for *every* class**

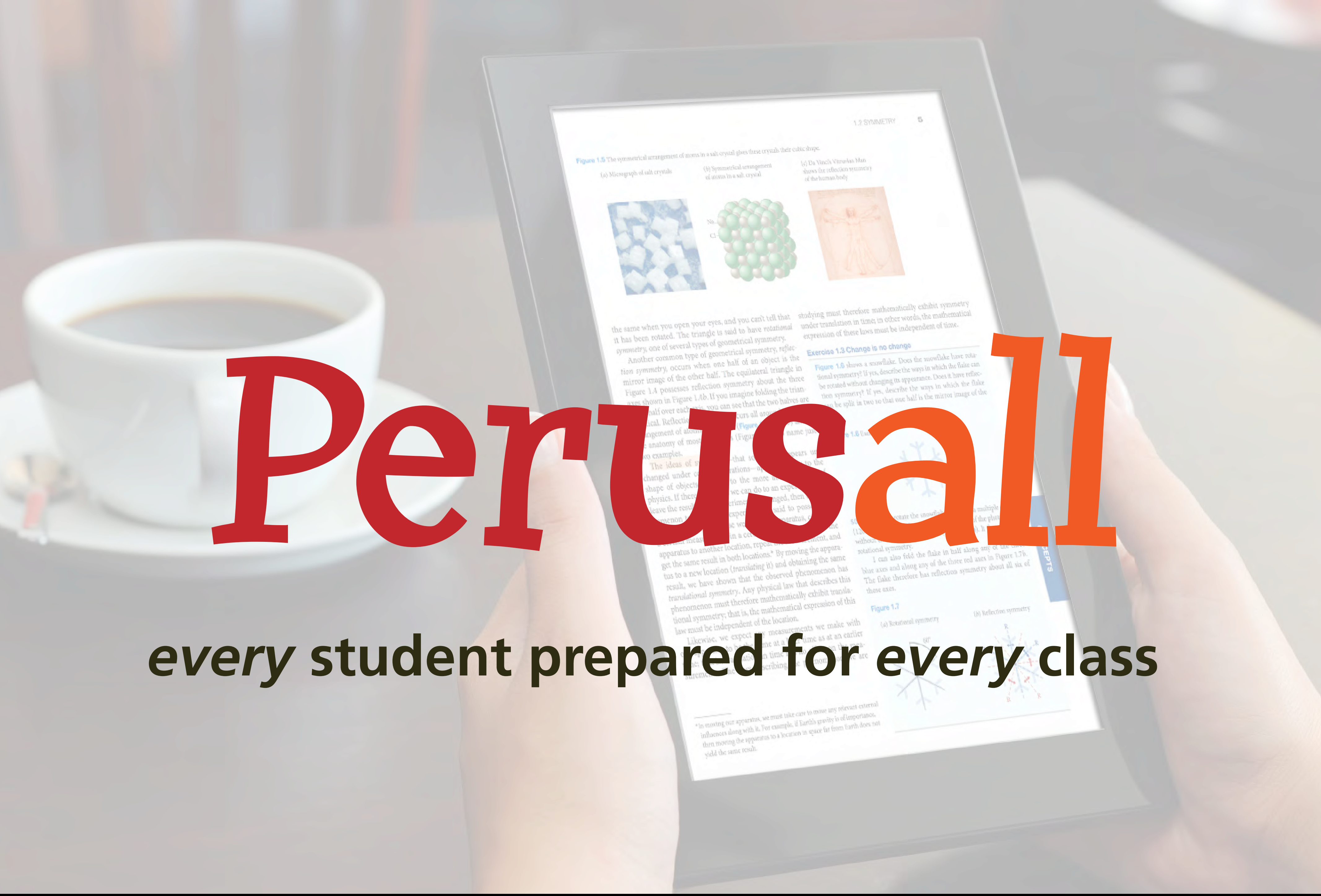
(without additional instructor effort)

1 design **2 approach**

Solution

turn out-of-class component

also into a social interaction!

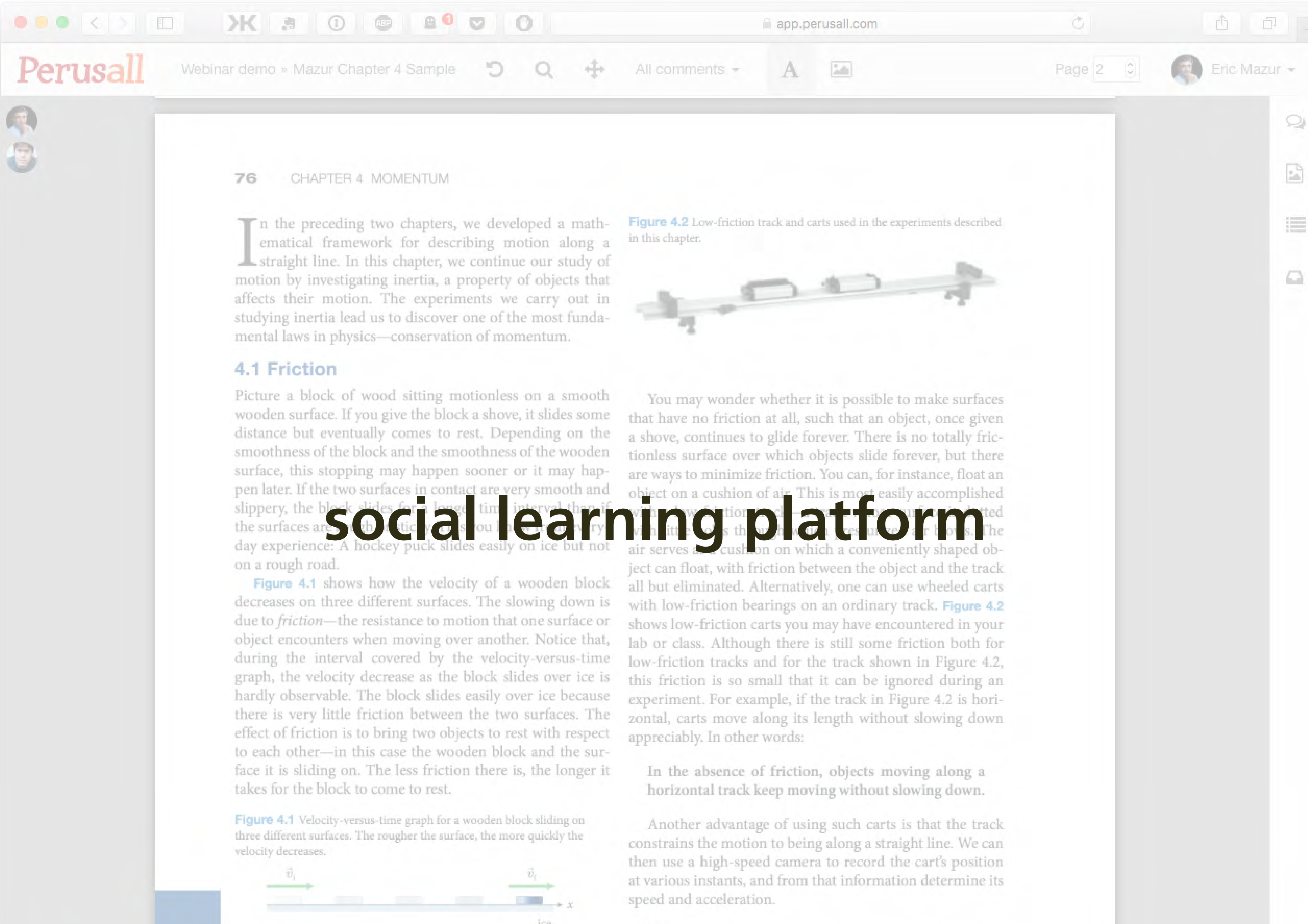


Perusall

every **student prepared for** ***every*** **class**

1 design

2 approach



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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 [illegible] the surfaces are [illegible] day experience: A hockey puck slides easily on ice but not on a rough road.

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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.

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 [illegible] air serves [illegible] 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.

social learning platform

1 design

2 approach

1 design

2 approach

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

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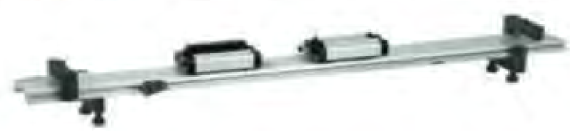

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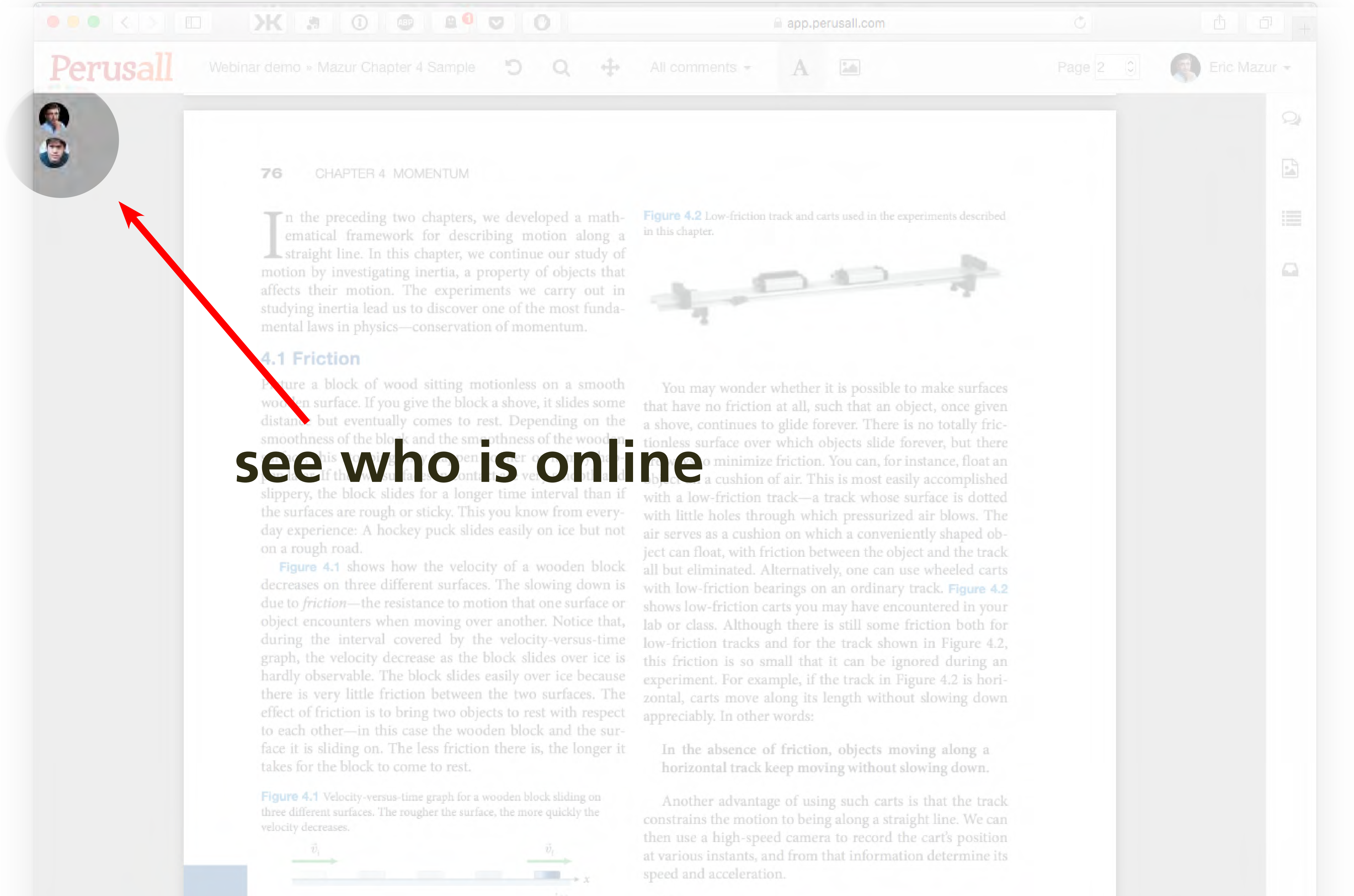
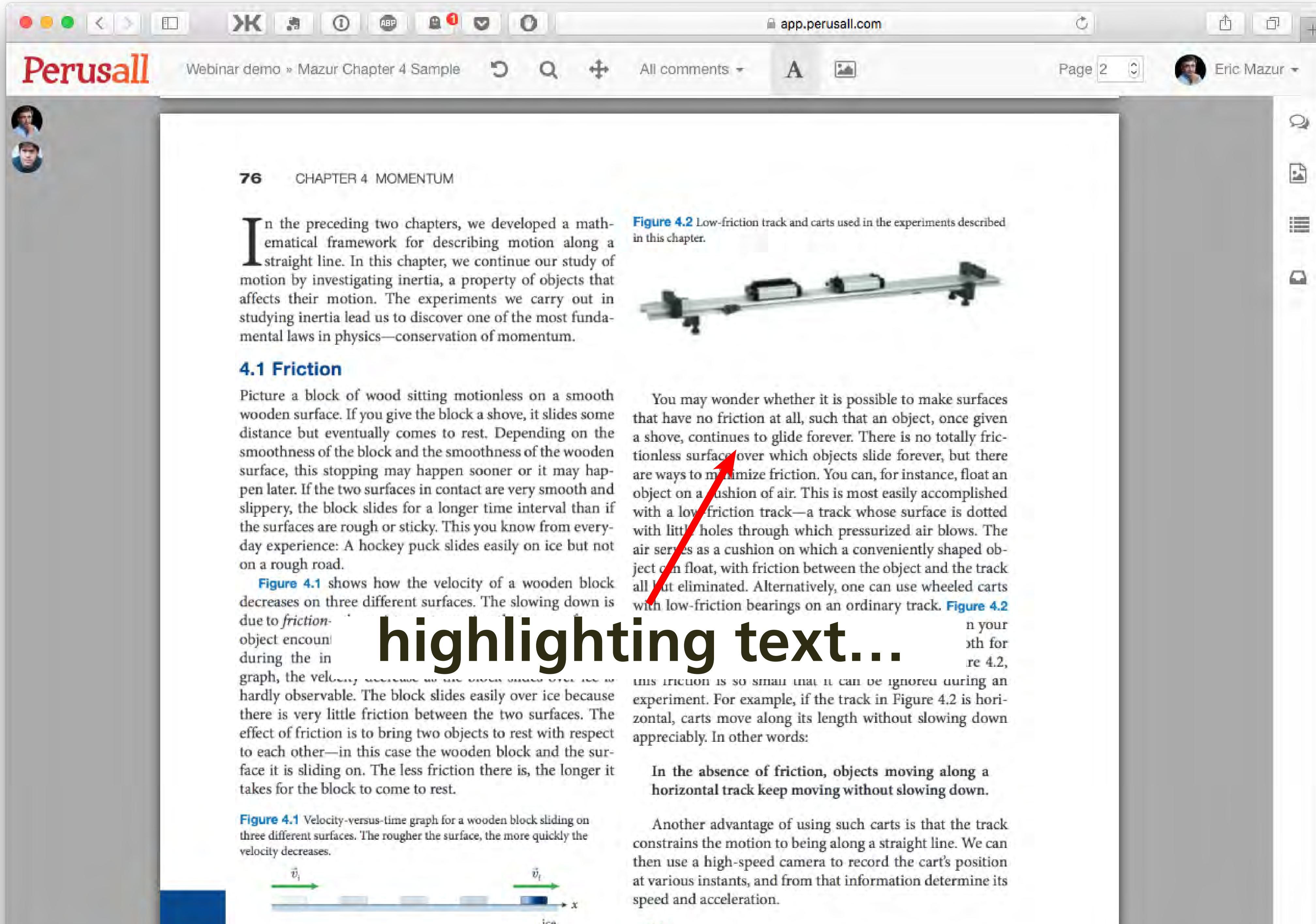
1 design 2 approach



1 design

2 approach



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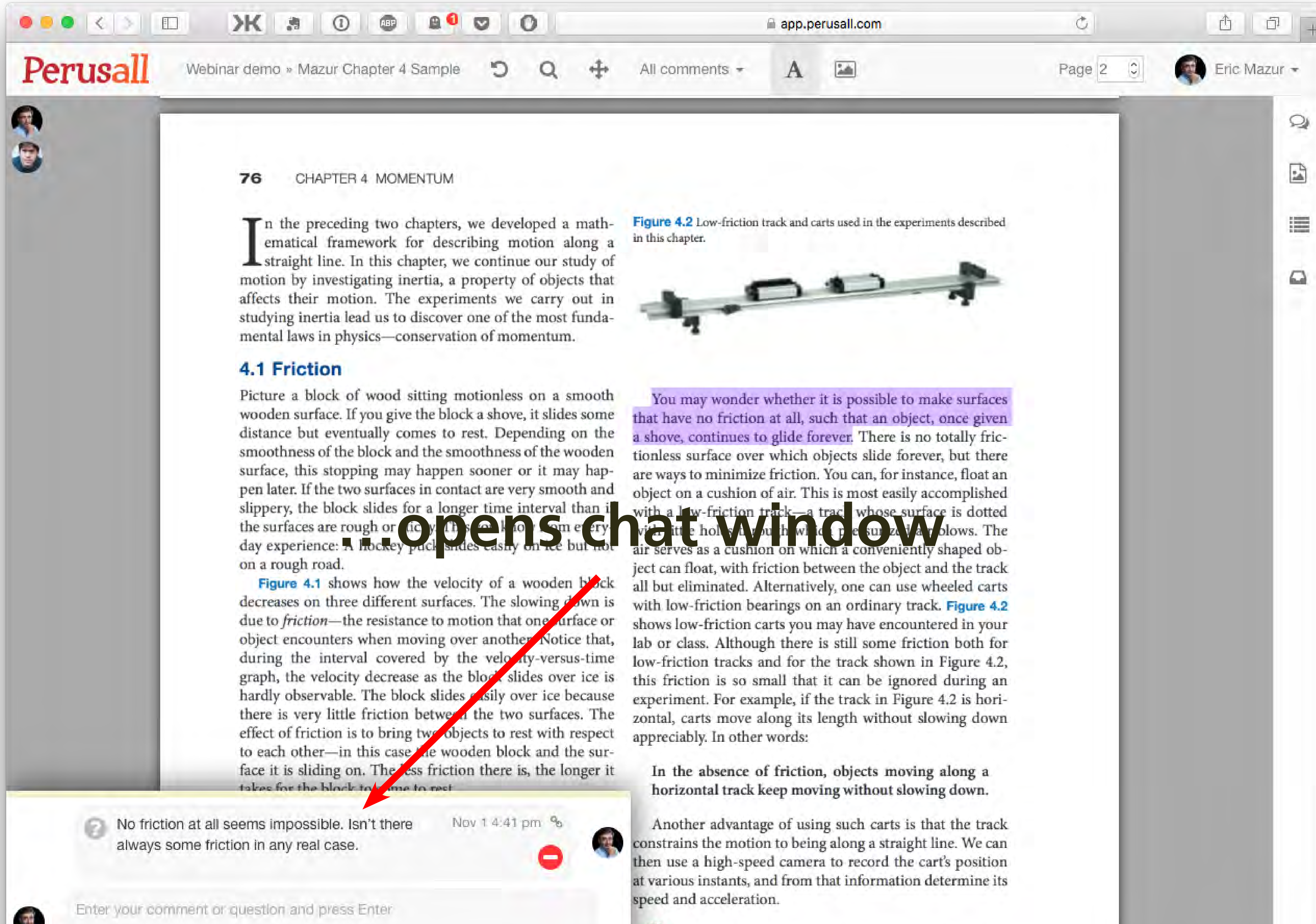
highlighting text…

1 design

2 approach



1 design

2 approach

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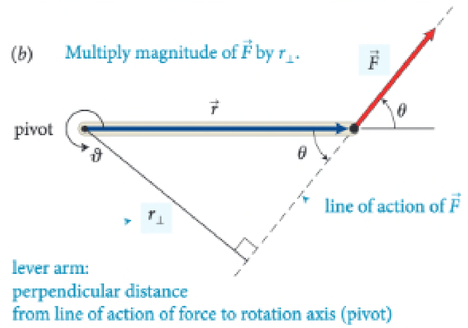
AP50 Fall 2015 » Chapter 12

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.

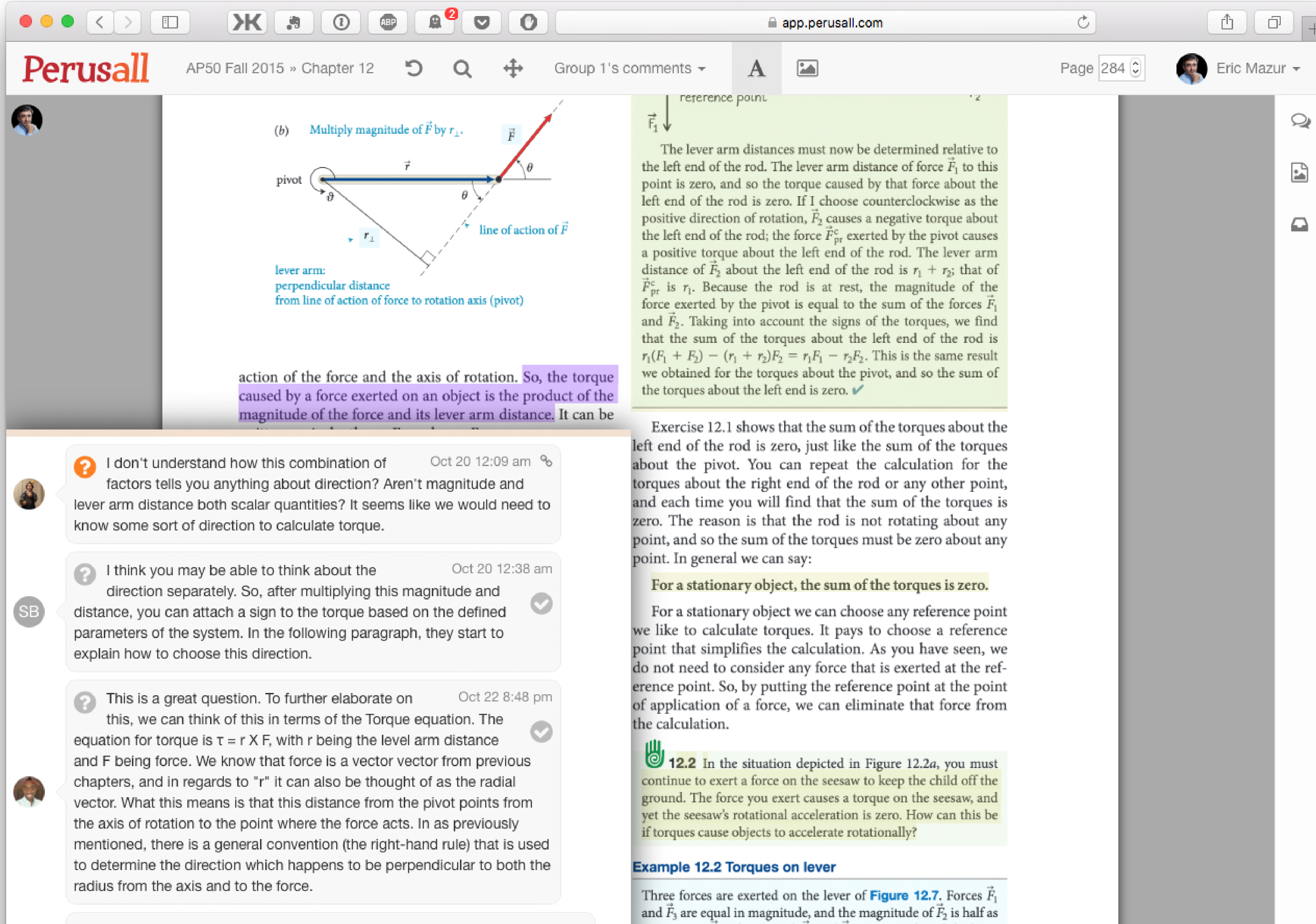
12.2 In the situation depicted in Figure 12.2*a*, you must continue to exert a force on the seesaw to keep the child off the ground. The force you exert causes a torque on the seesaw, and yet the seesaw's rotational acceleration is zero. How can this be if torques cause objects to accelerate rotationally?

Example 12.2 Torques on lever

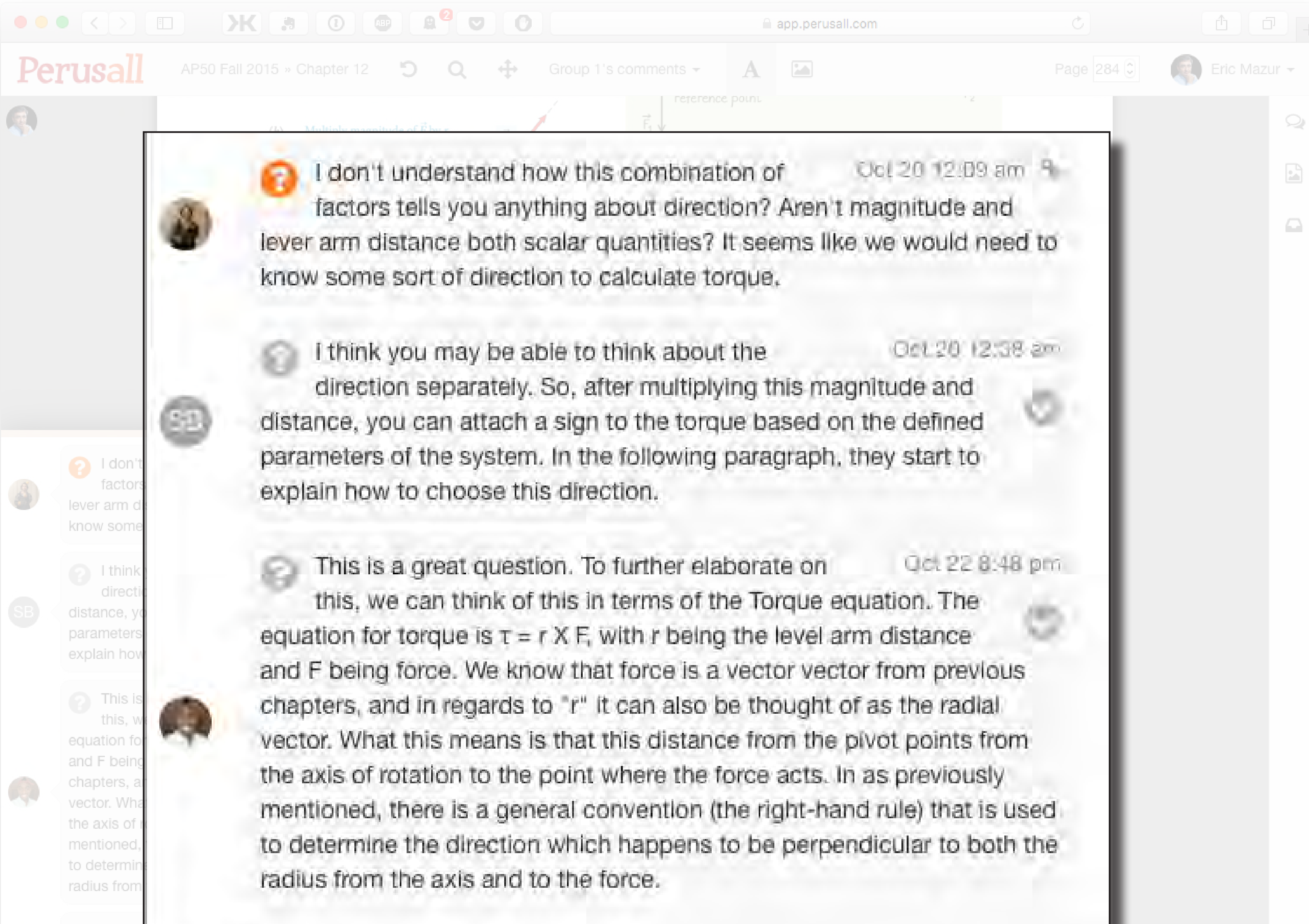
Three forces are exerted on the lever of Figure 12.7. Forces $\vec{F}_1$ and $\vec{F}_3$ are equal in magnitude, and the magnitude of $\vec{F}_2$ is half as great. Force $\vec{F}_1$ is horizontal, $\vec{F}_2$ and $\vec{F}_3$ are vertical, and the lever

1 design

2 approach

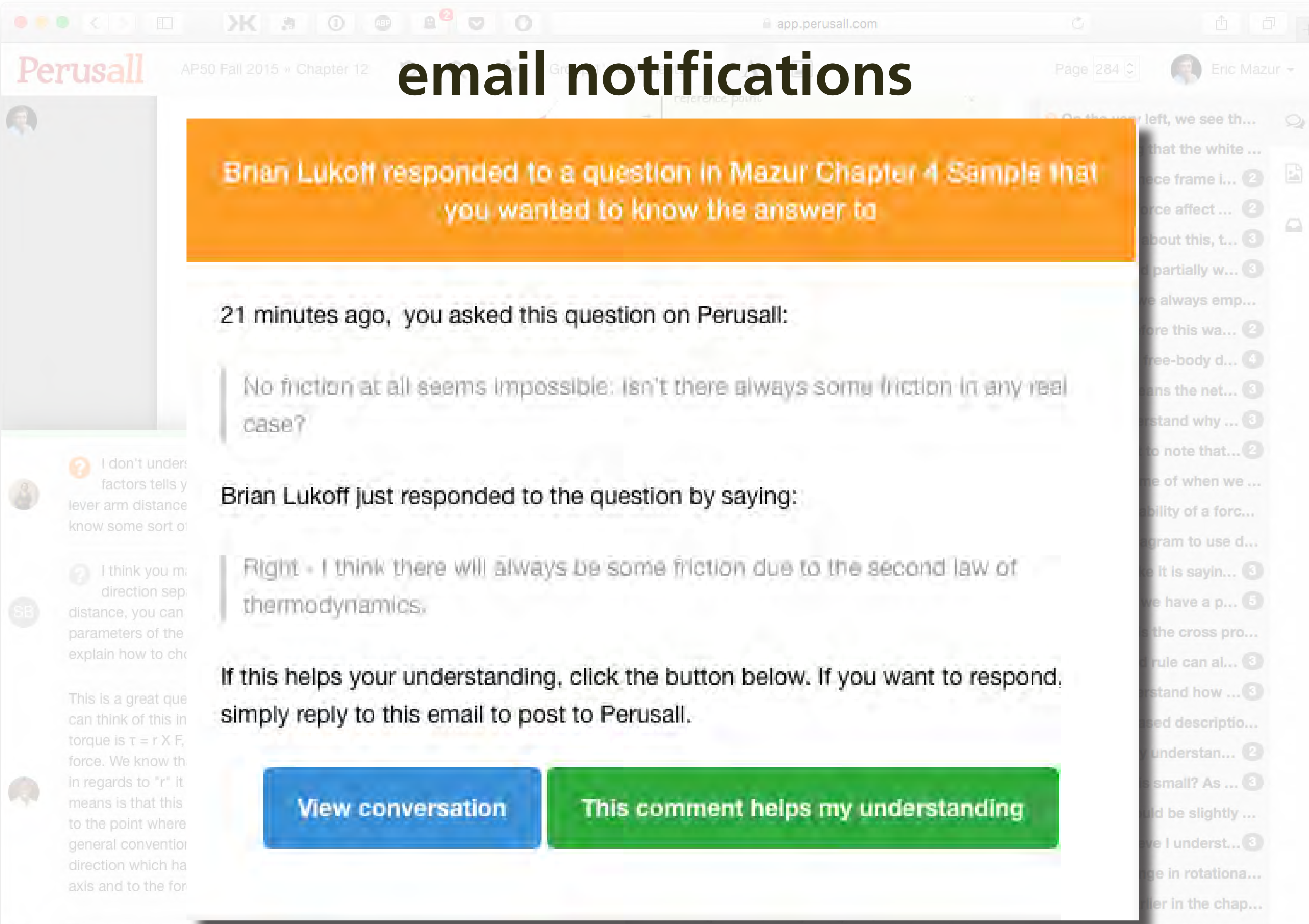


1 design 2 approach



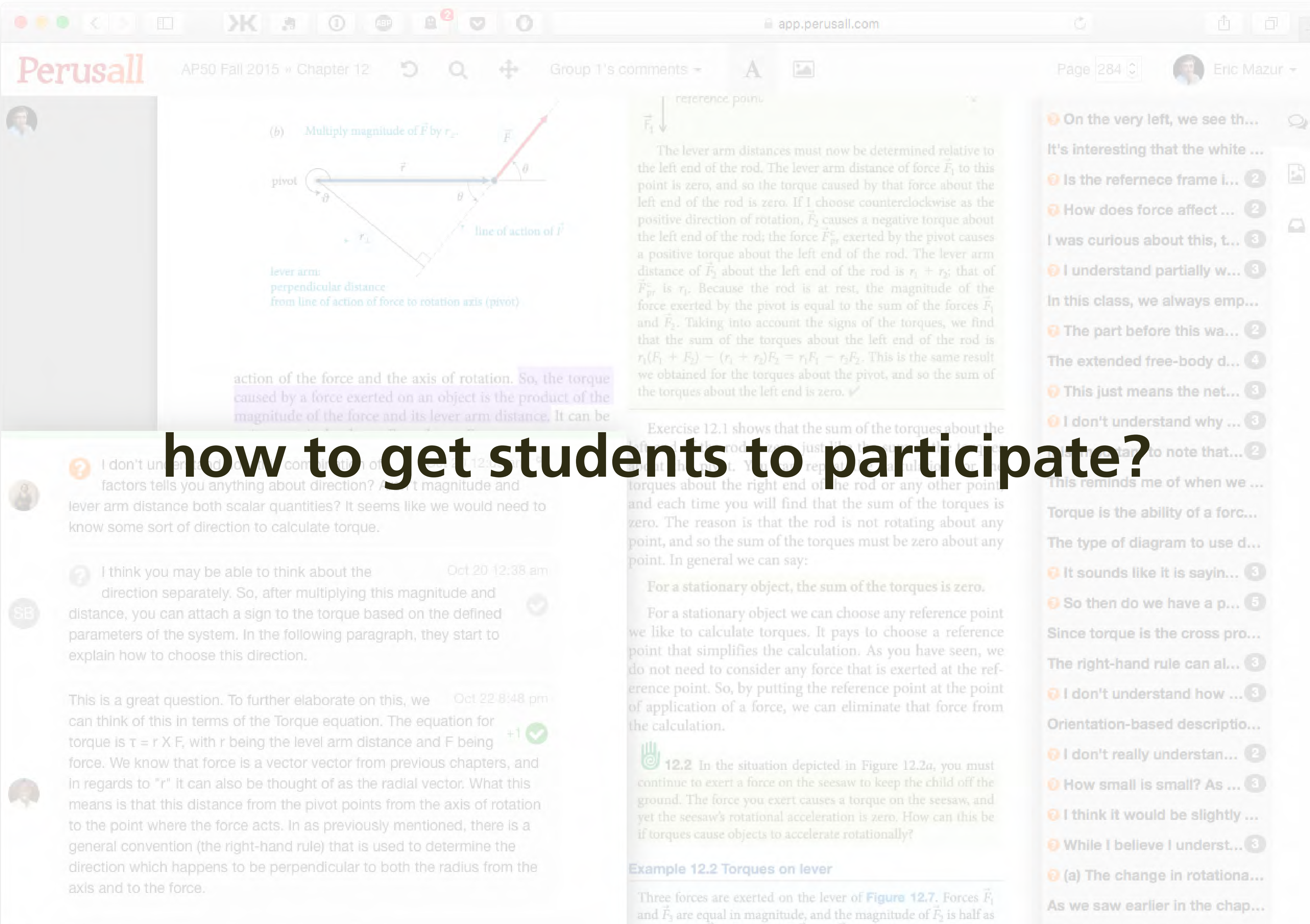
1 **design** **2** **approach**

email notifications



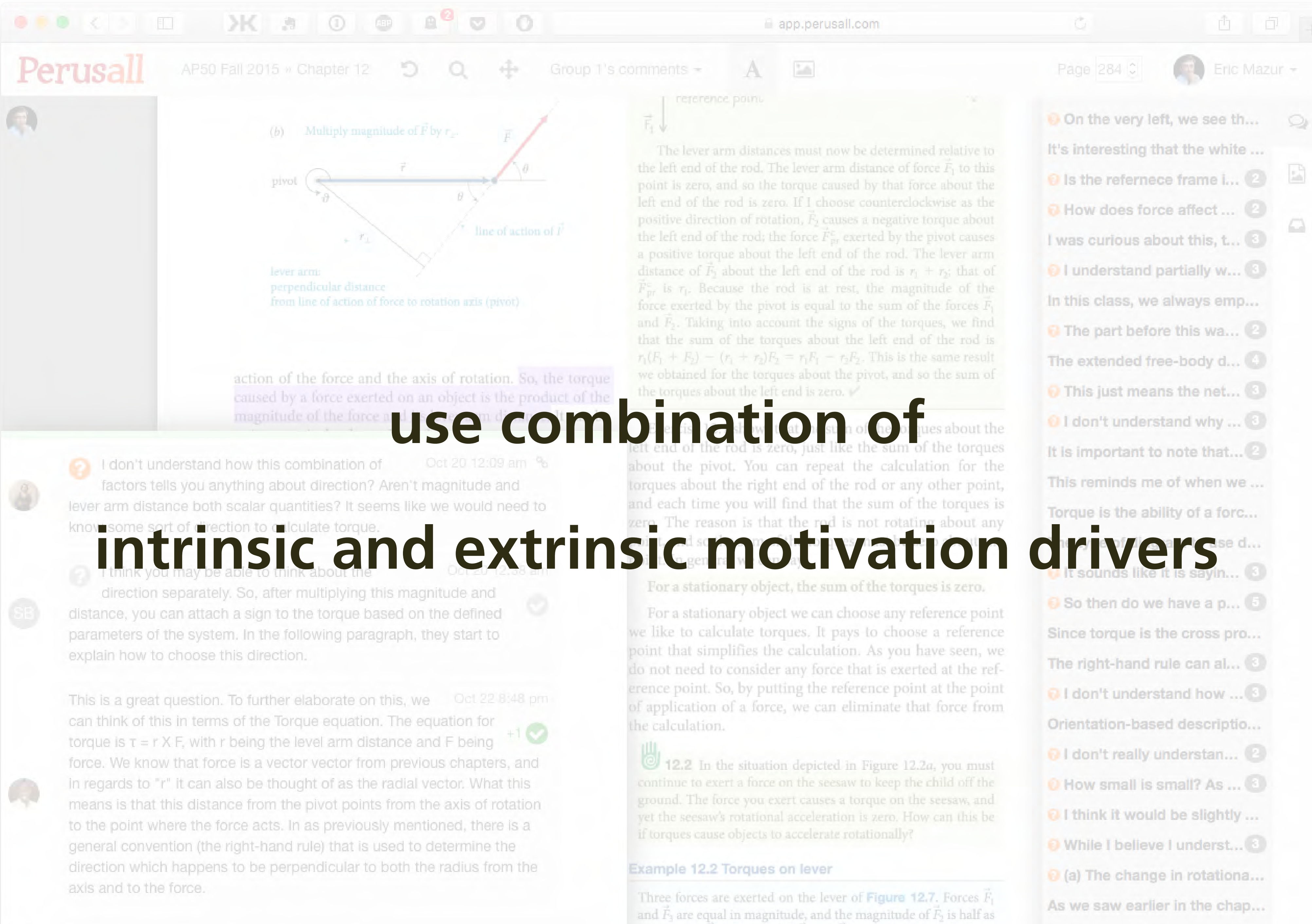
1 design

2 approach



how to get students to participate?

1. design
2. approach

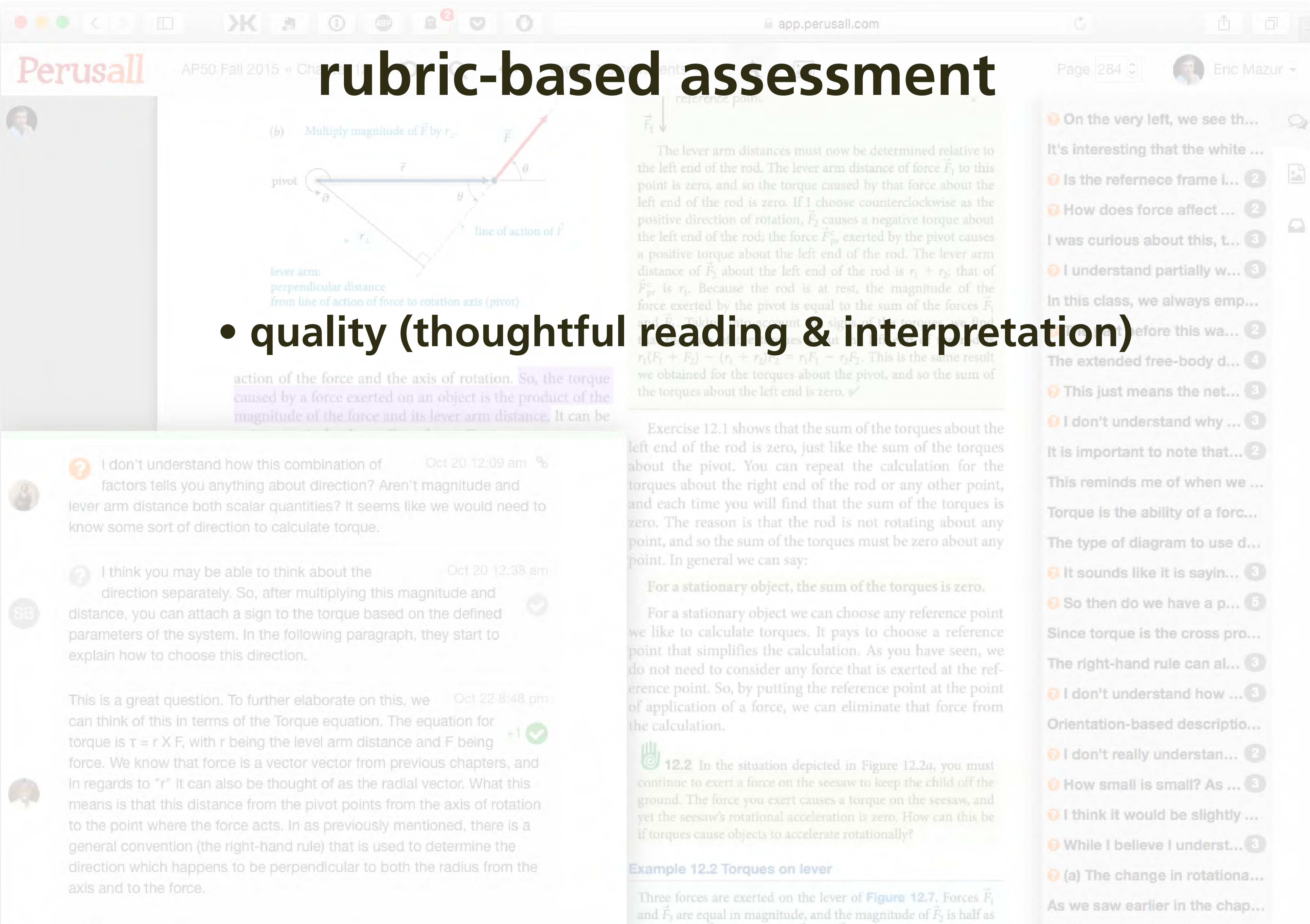


use combination of intrinsic and extrinsic motivation drivers

1 design **2** approach

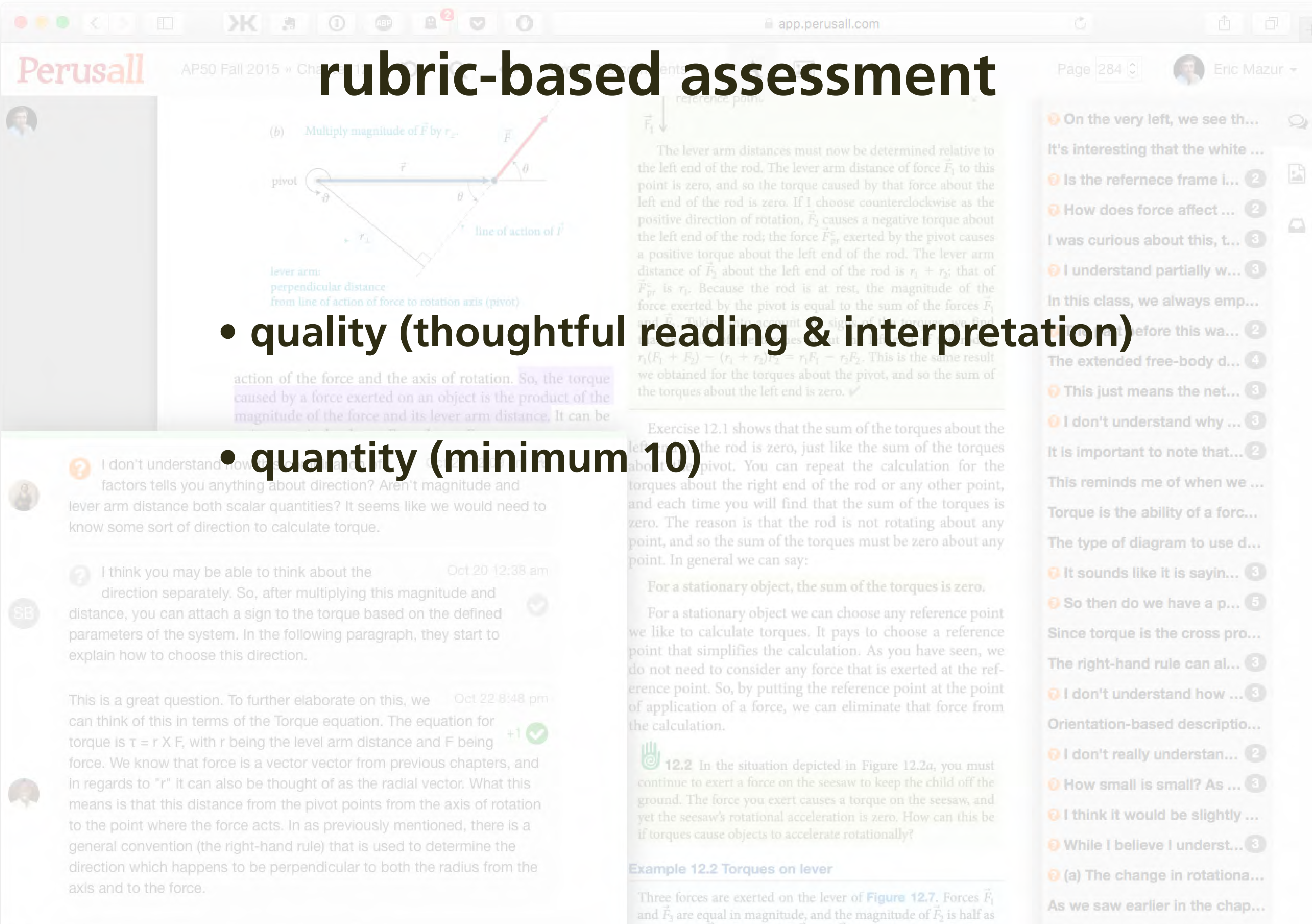
rubric-based assessment

- quality (thoughtful reading & interpretation)



1 design 2 approach

rubric-based assessment



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

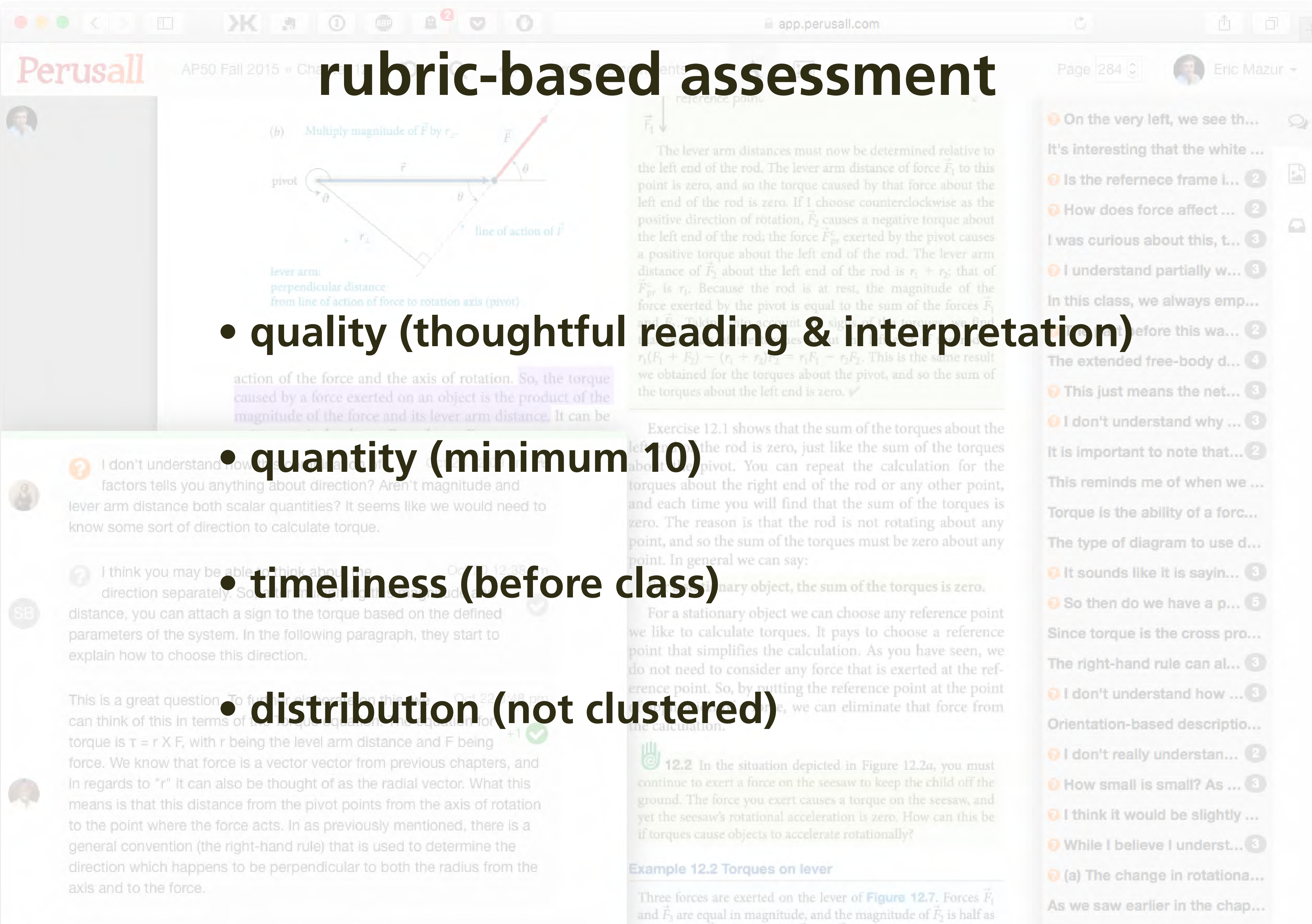
1 design 2 approach

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)

rubric-based assessment

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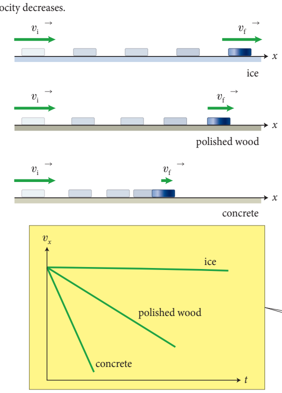


CONCEPTS

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 absence 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

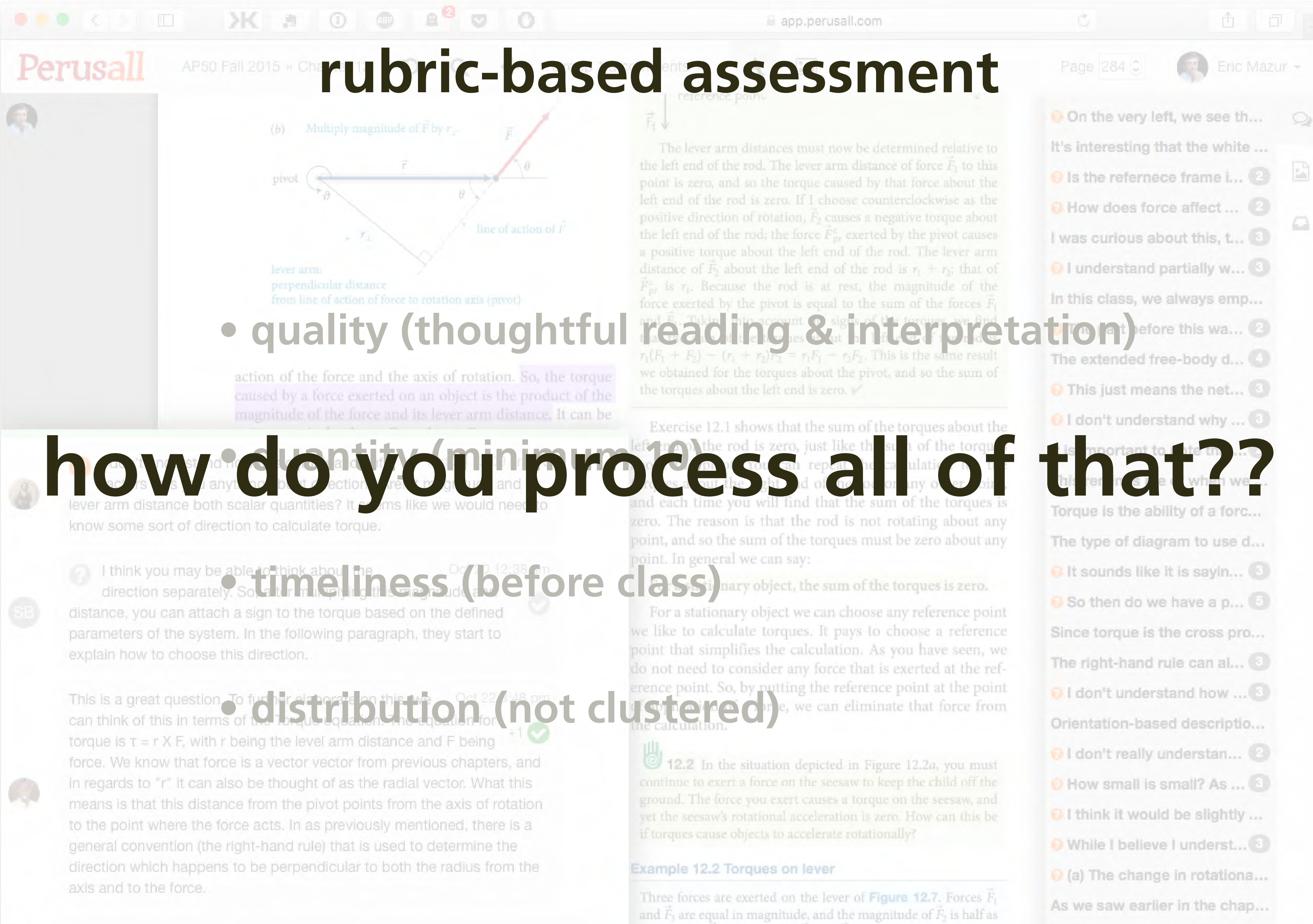
2 approach

rubric-based assessment

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

over 20,000 annotations!

1 design   2 approach



rubric-based assessment

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

how do you process all of that??

❶ design ❷ approach

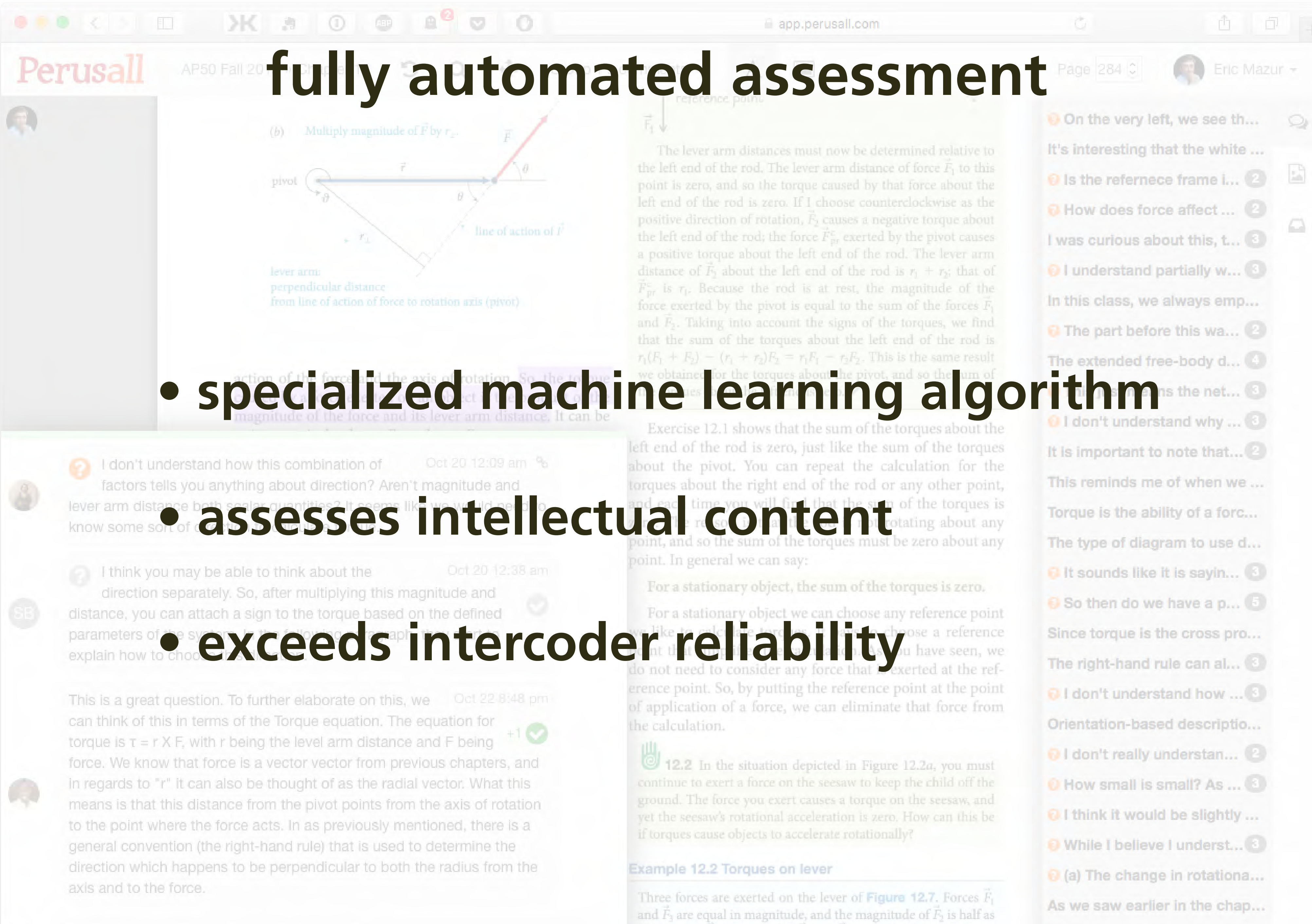
rubric-based assessment

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

how do you process all of that??

fully automated assessment

1 design 2 approach

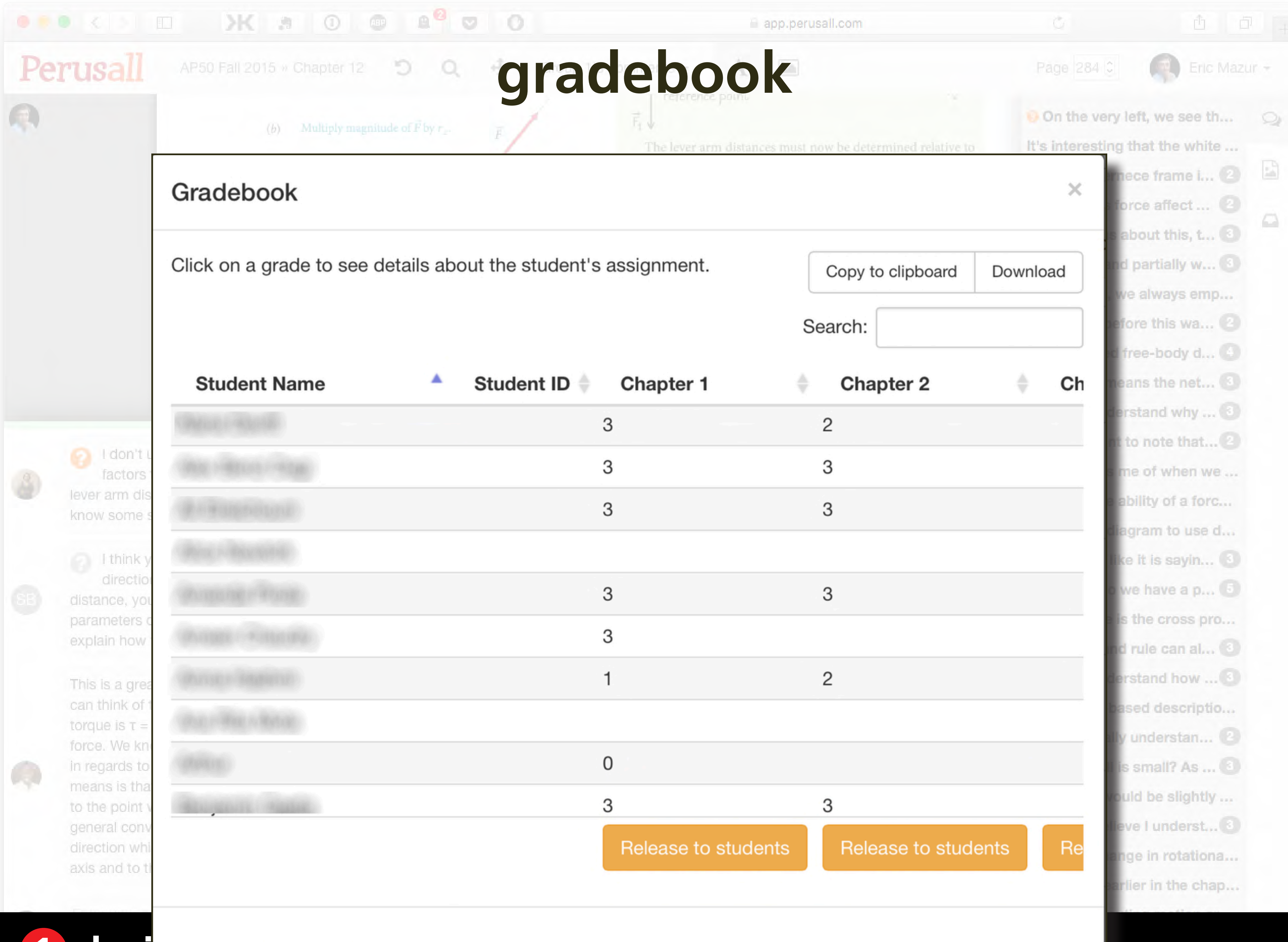


fully automated assessment

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

1 design   2 approach

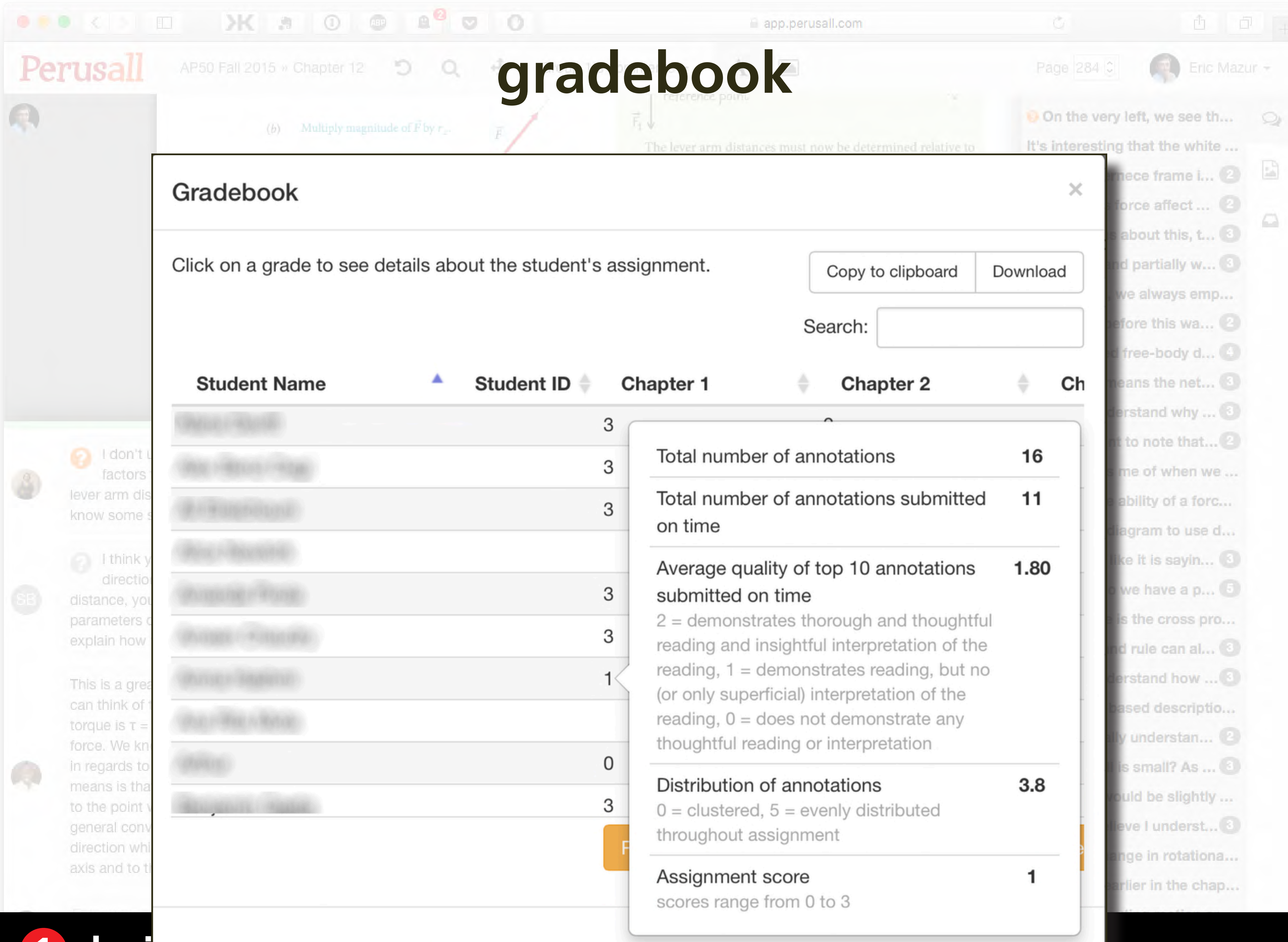
gradebook



1 design

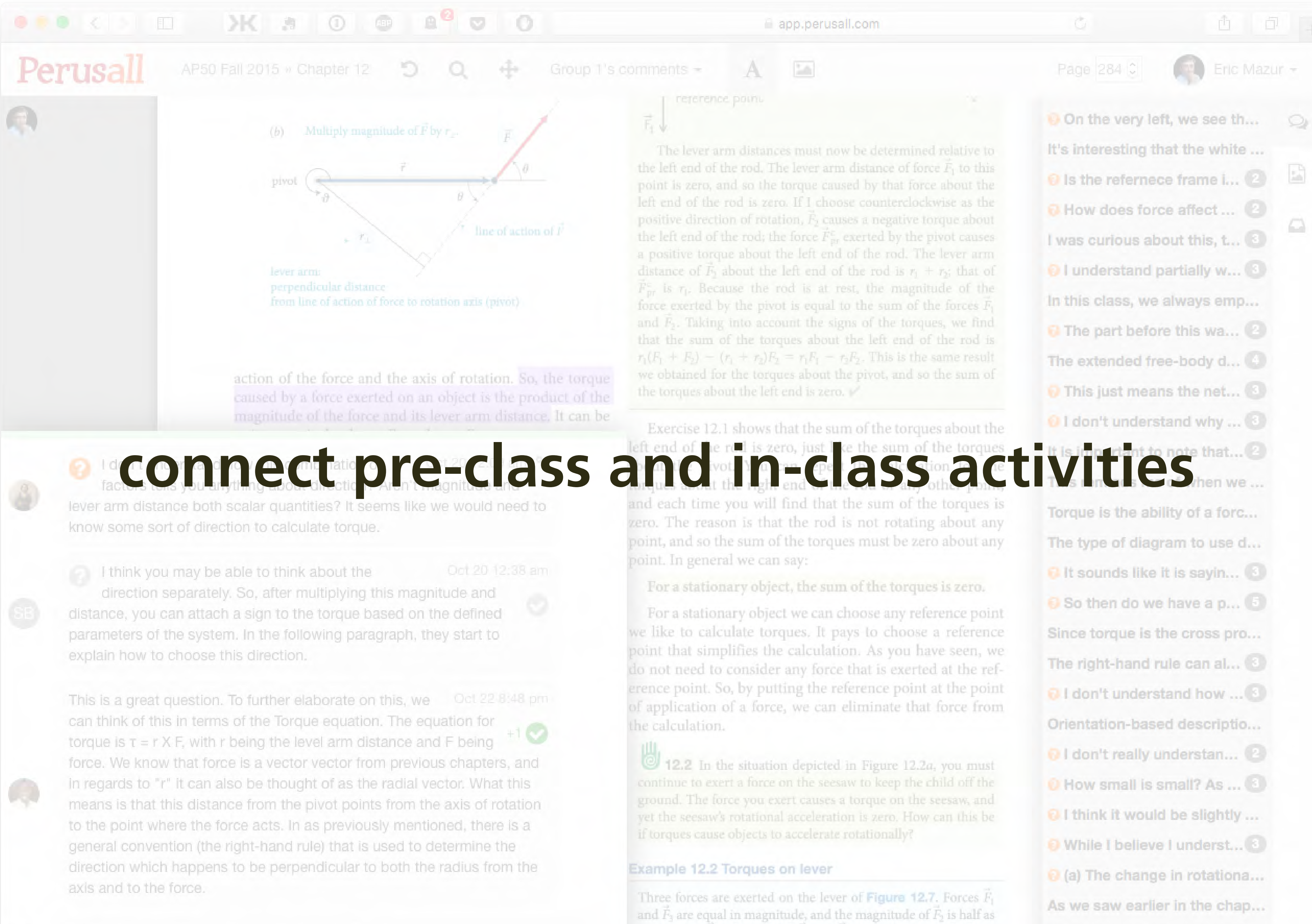
2 approach

gradebook



1 design

2 approach

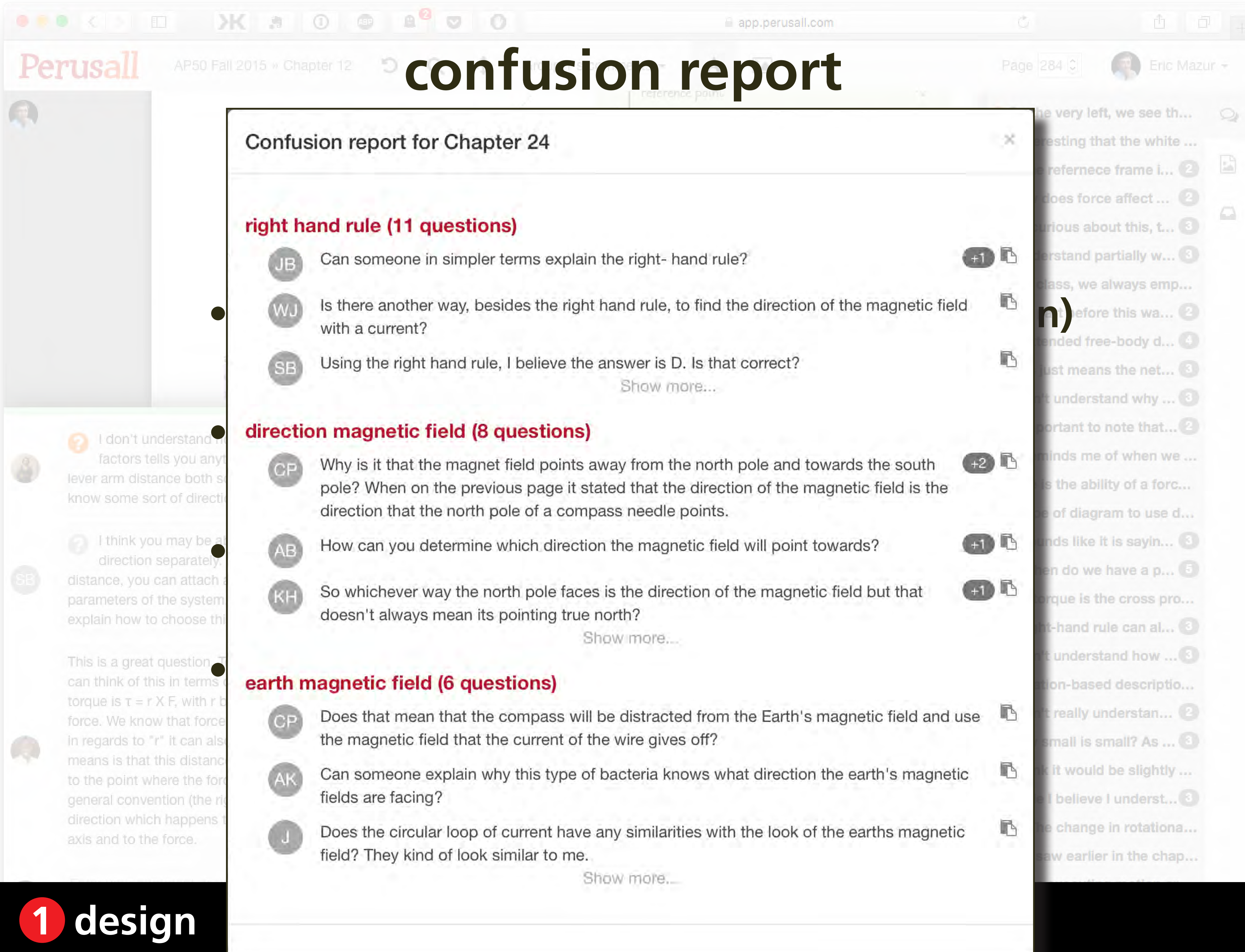


connect pre-class and in-class activities

❶ design

❷ approach

confusion report



1 design

motivating factors

Intrinsic:

- social interaction

❶ design ❷ approach

motivating factors

Intrinsic:

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

❶ design ❷ 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

1 design **2 approach**

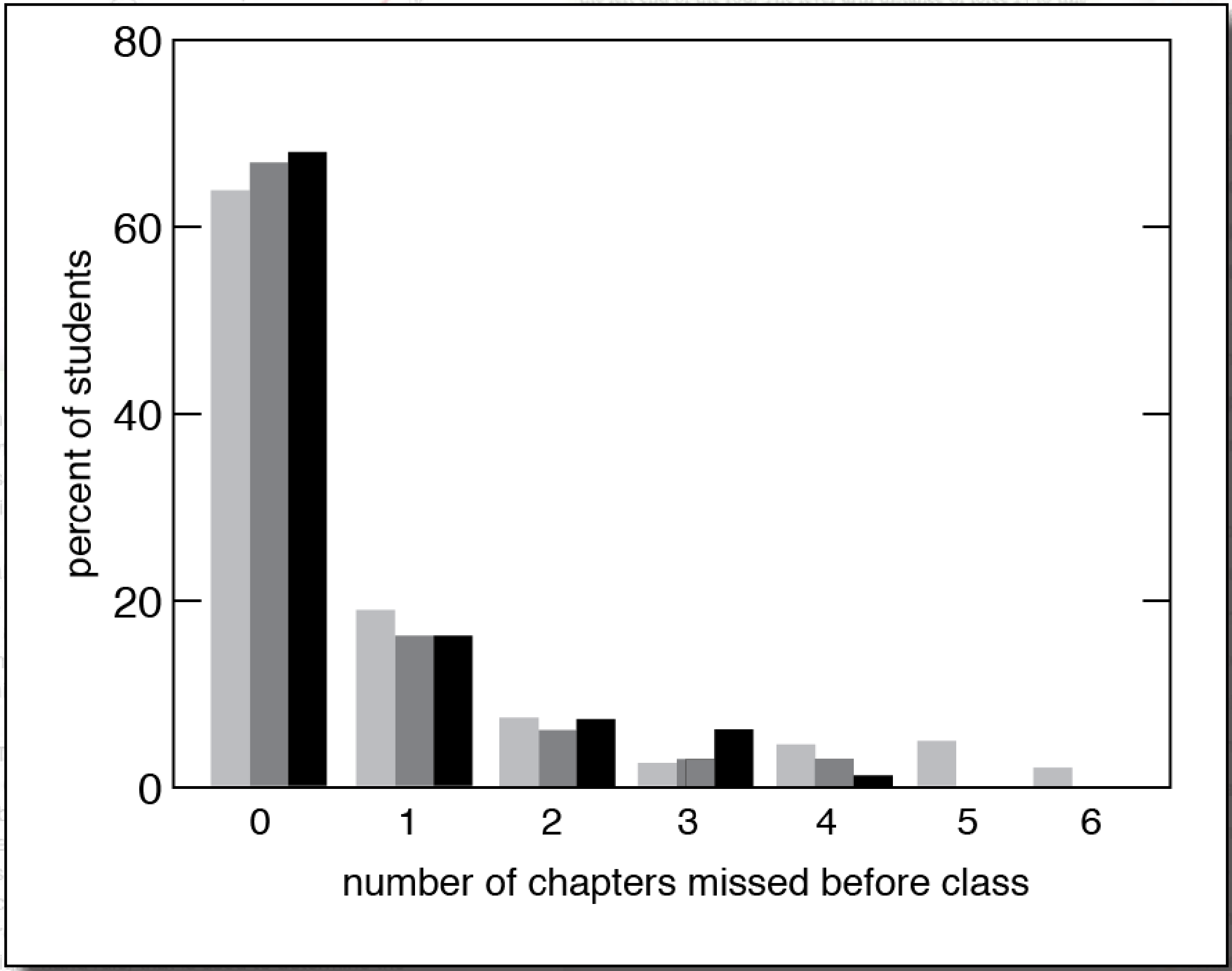
motivating factors

"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."

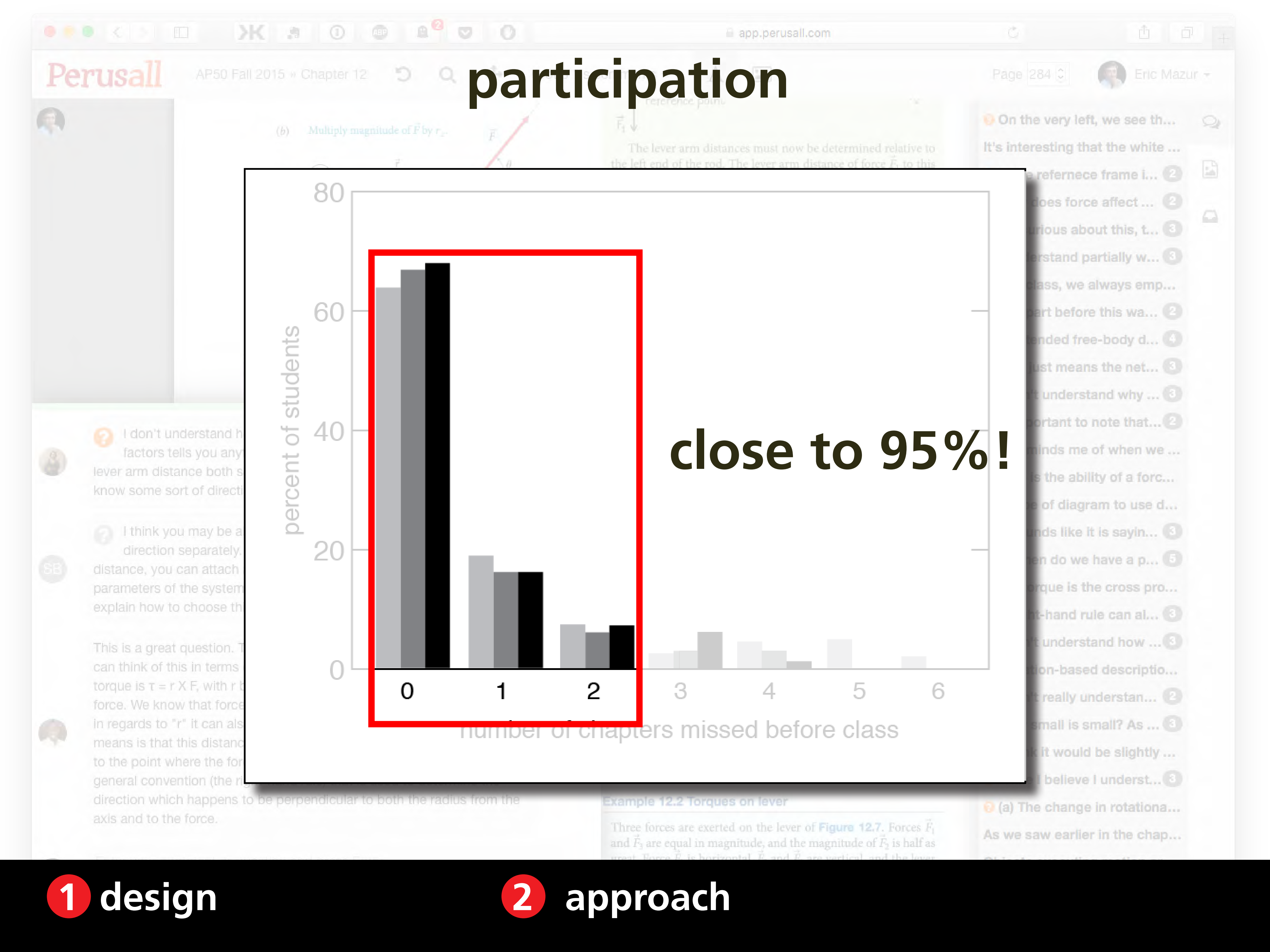
Ohio State student

1 design **2 approach**

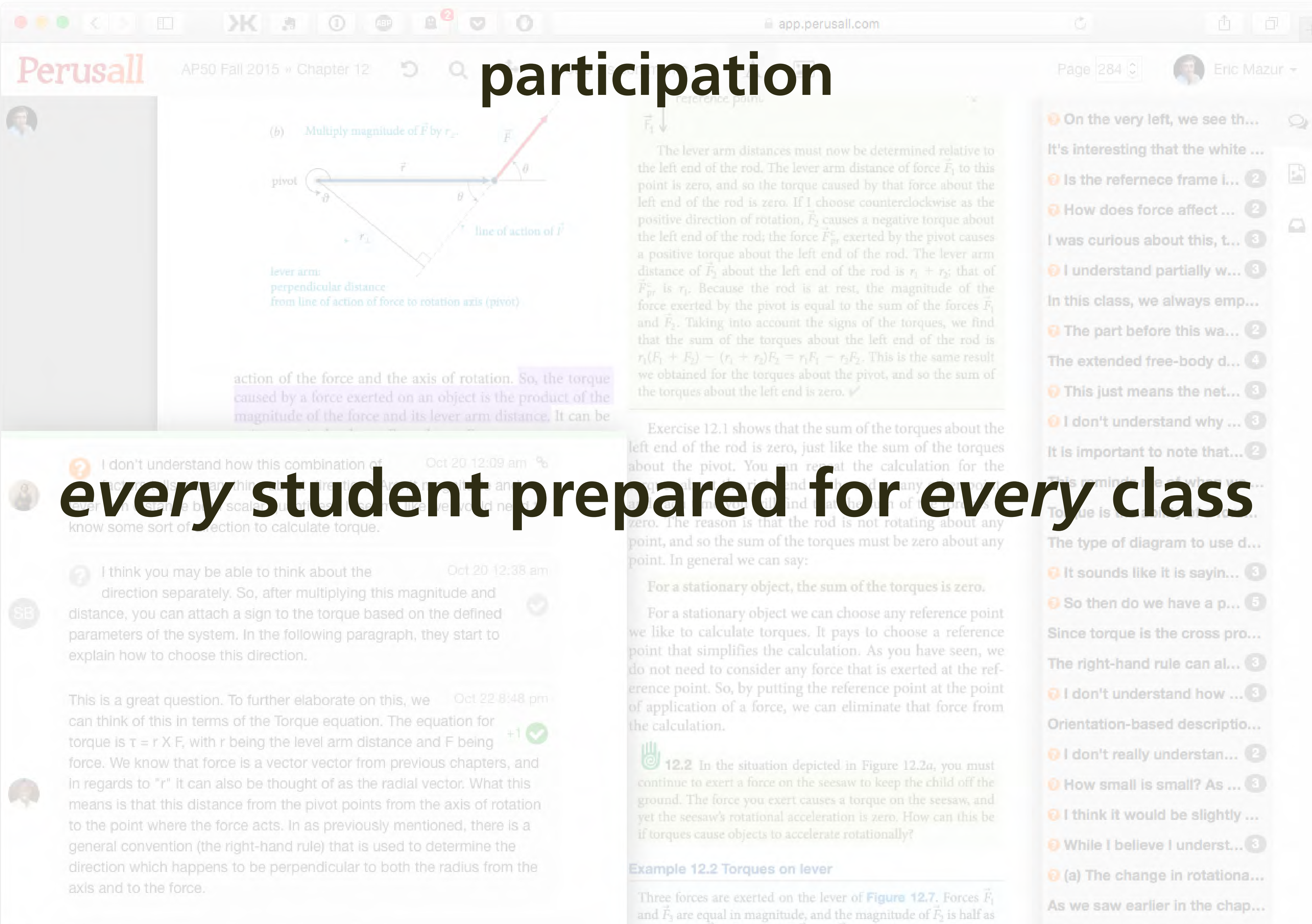
participation



❶ design ❷ approach



participation
80
60
40
20
0
percent of students
0
1
2
3
4
5
6
number of chapters missed before class
close to 95%!
1 design
2 approach



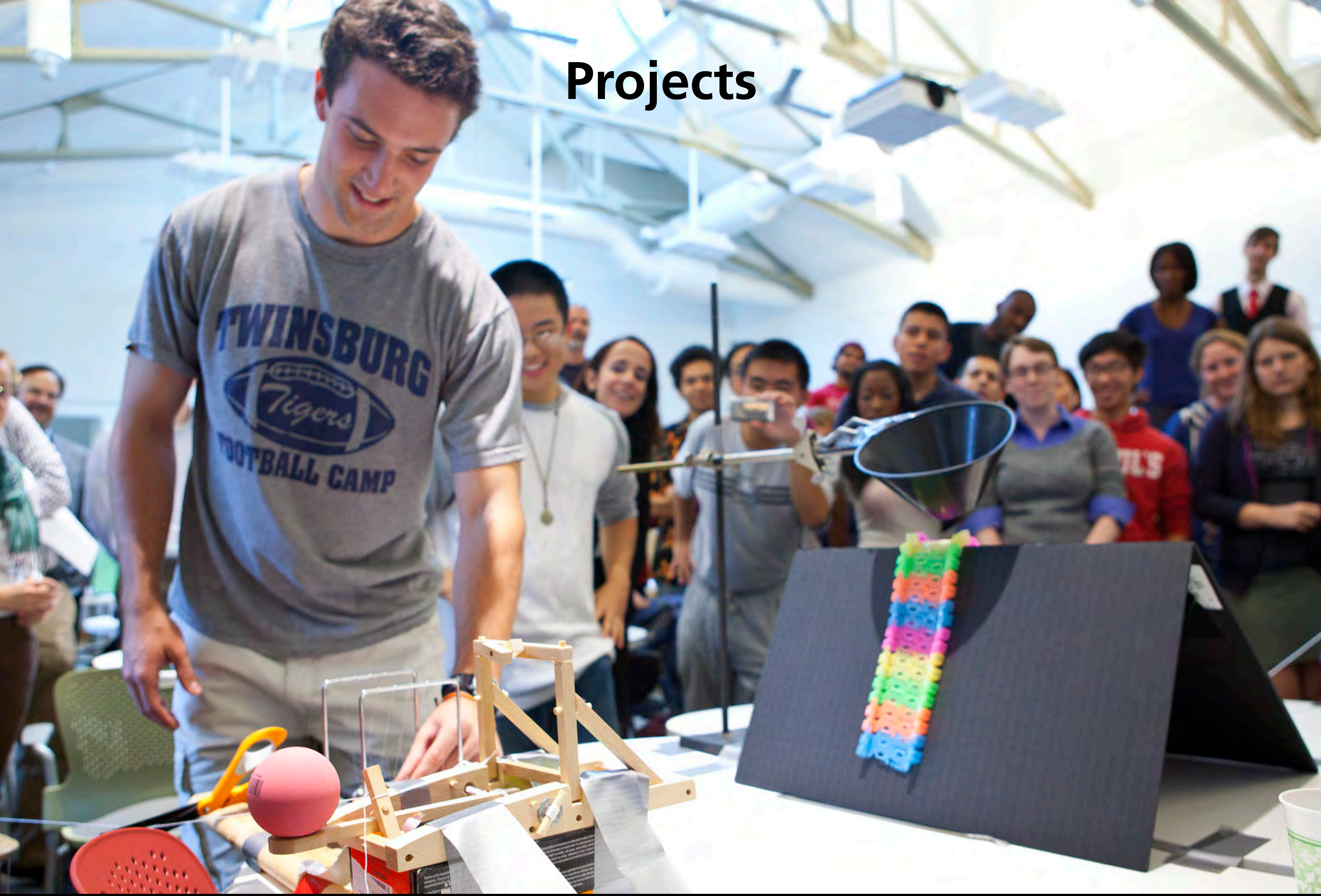
participation

every student prepared for *every* class

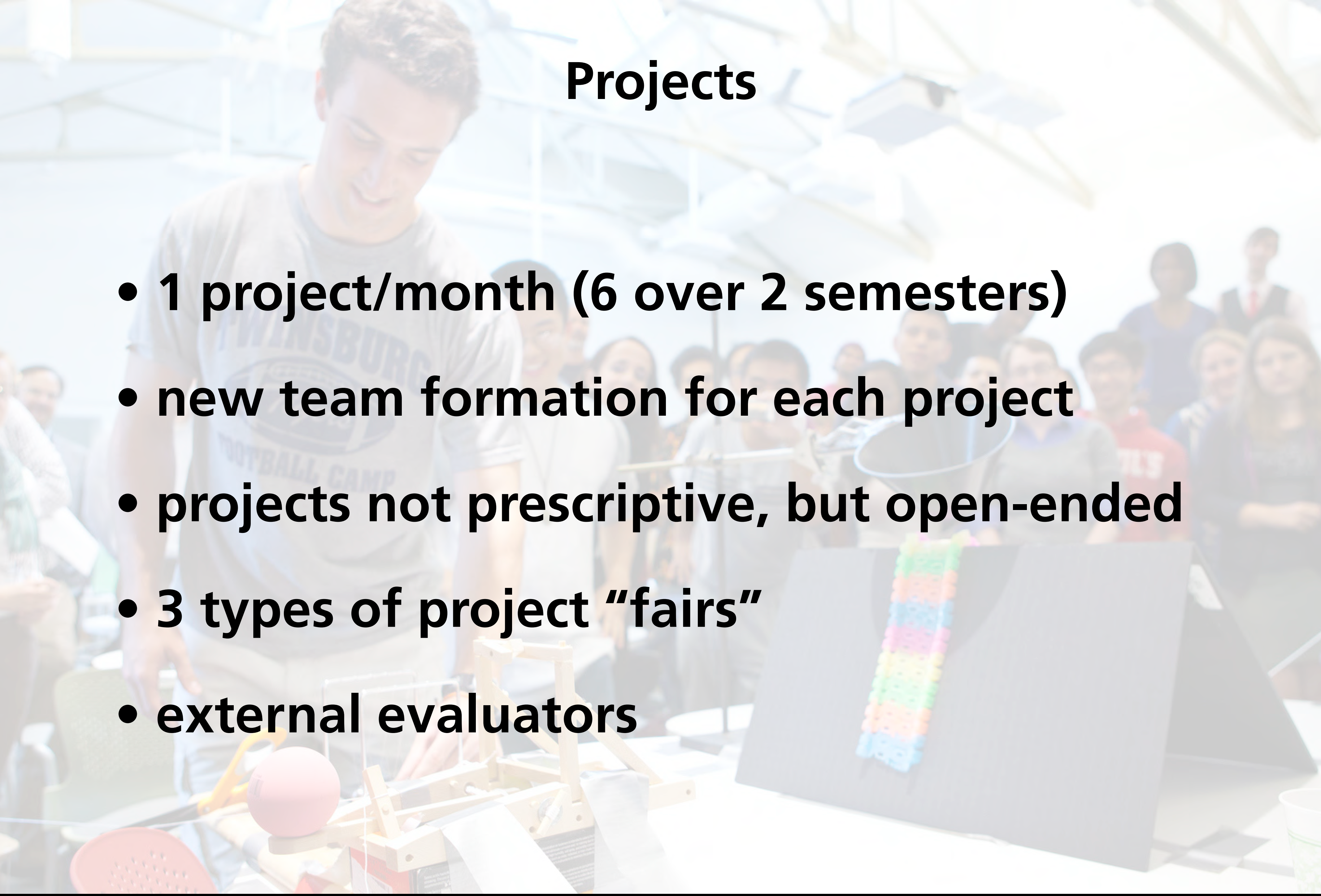
1 design

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

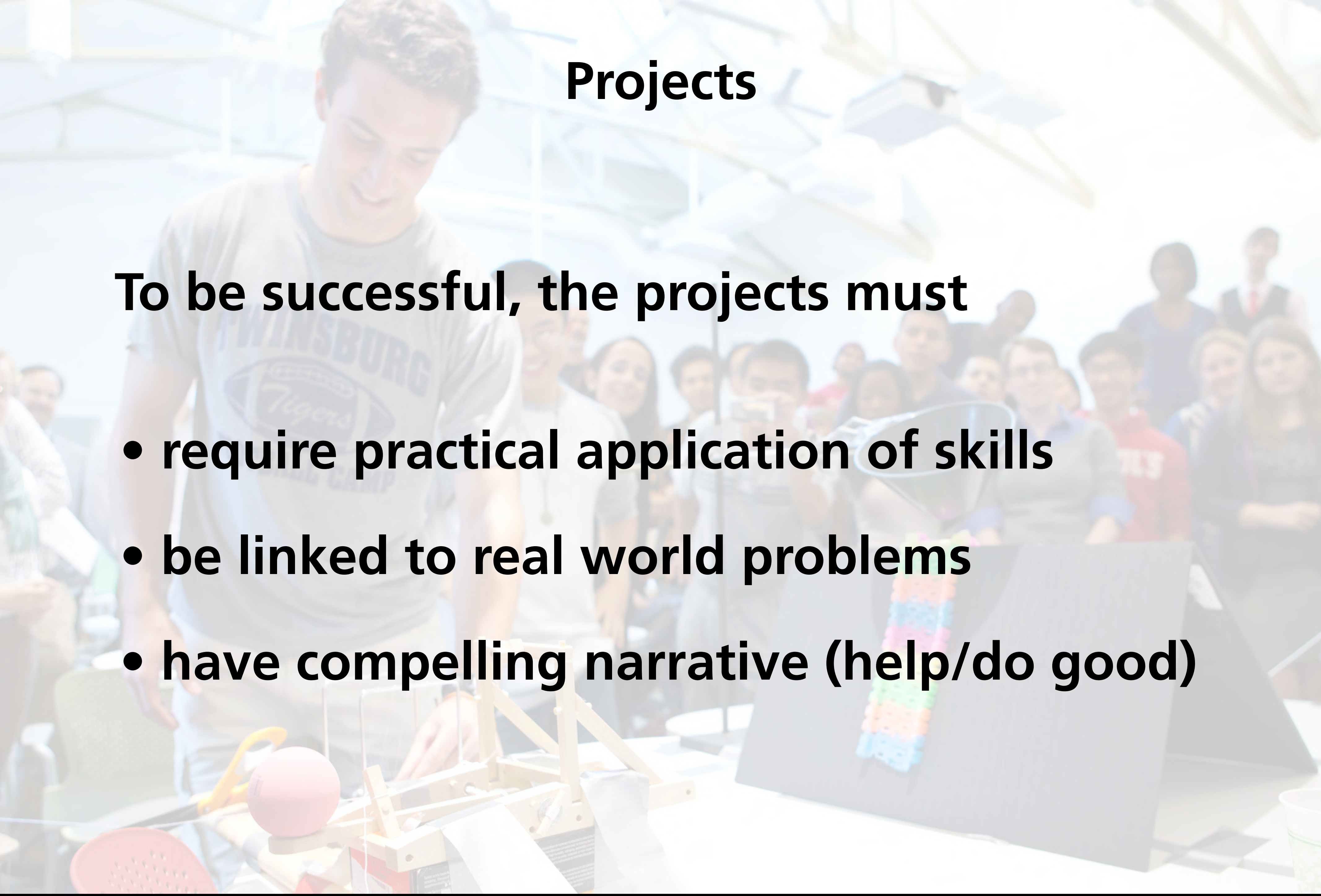
1 design   2 approach

Projects

Rule-based team formation using GroupEng

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

www.GroupEng.org



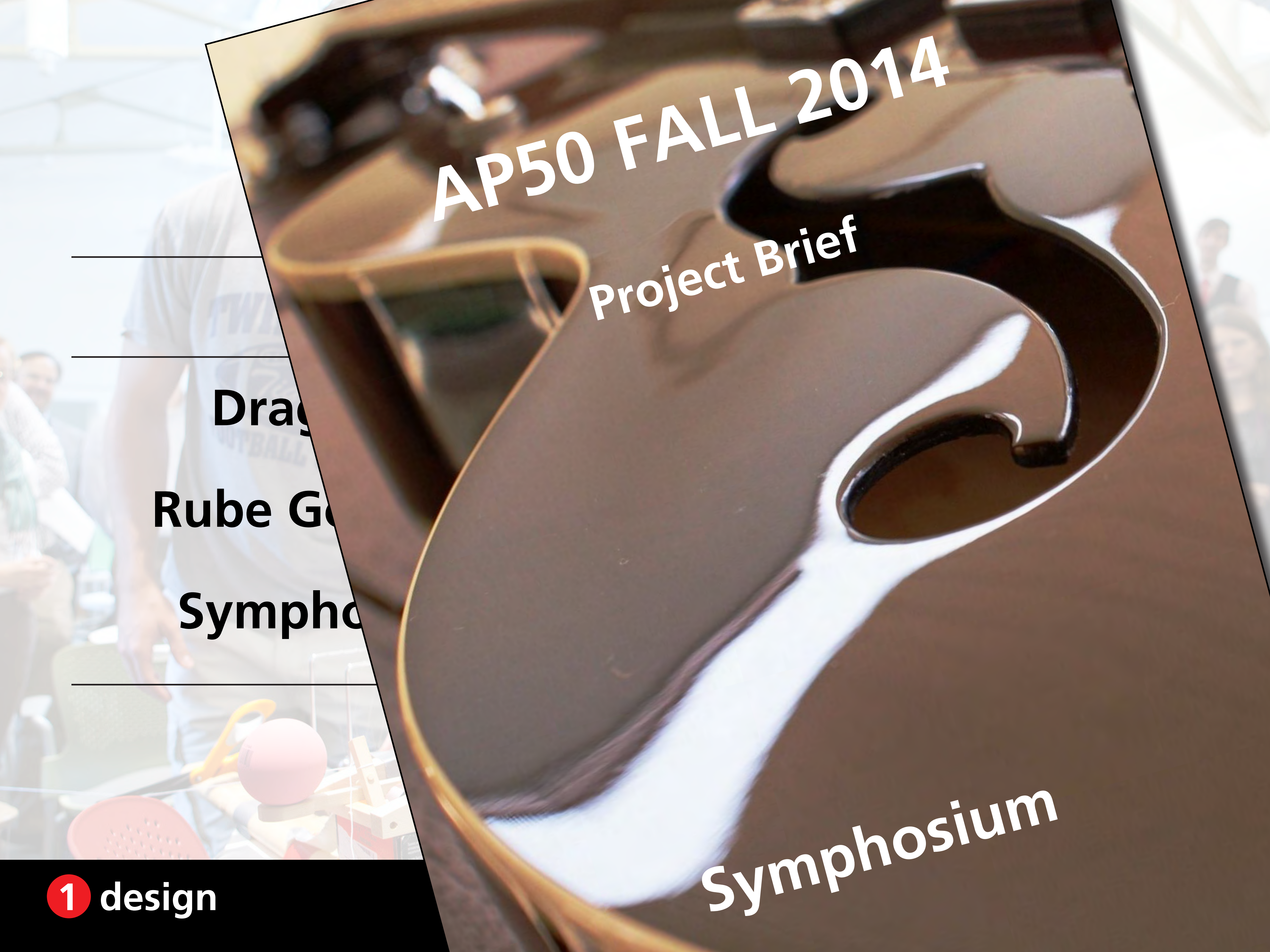
Projects

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


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

1 design

2 approach

Projects

❶ design ❷ approach

Projects

Build a beautifully sounding instrument from recycled parts

1 design **2** approach

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)

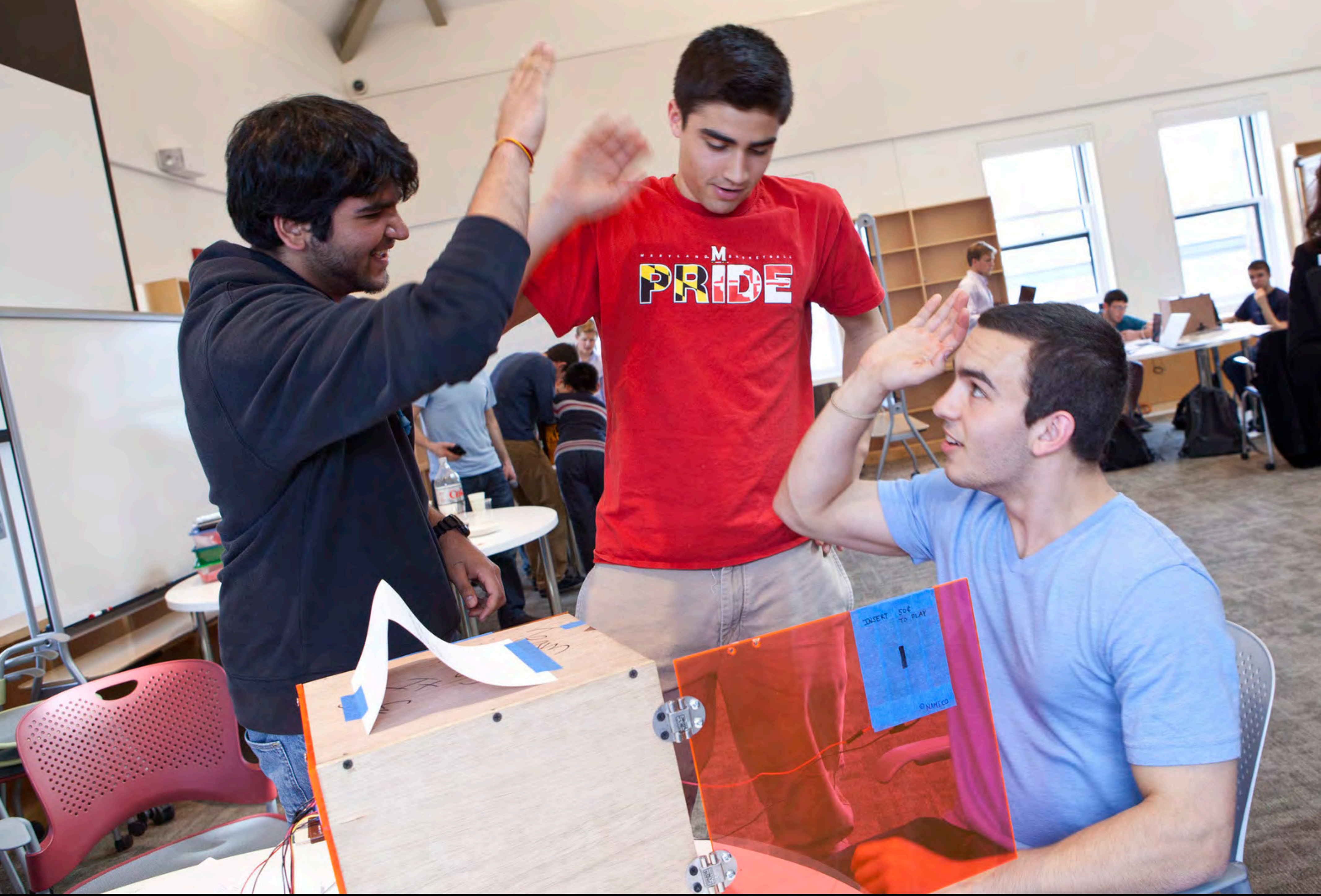
1 design

2 approach

1 design 2 approach

competition instead of

social good/empathy as motivator



1 design 2 approach

In-class activities

1 design

2 approach

In-class activities

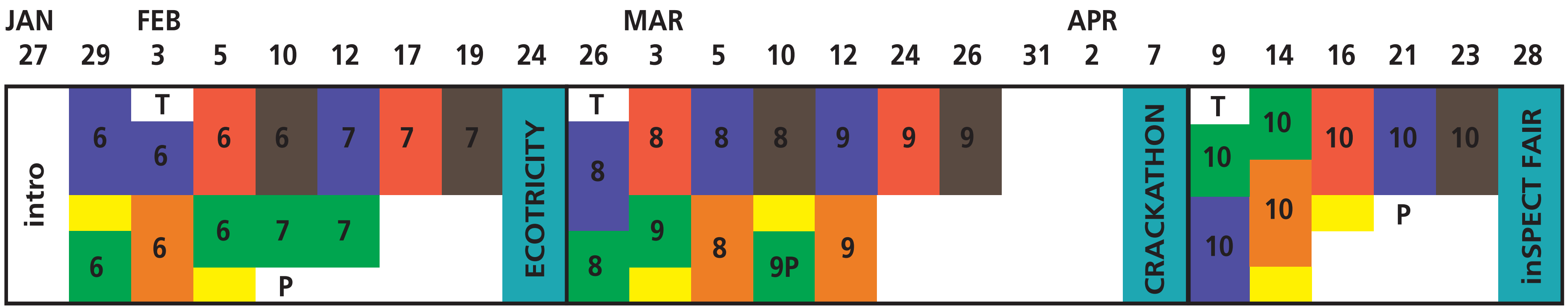
2 weekly 3-hour class periods

In-class activities

blend of 6 "best practices"

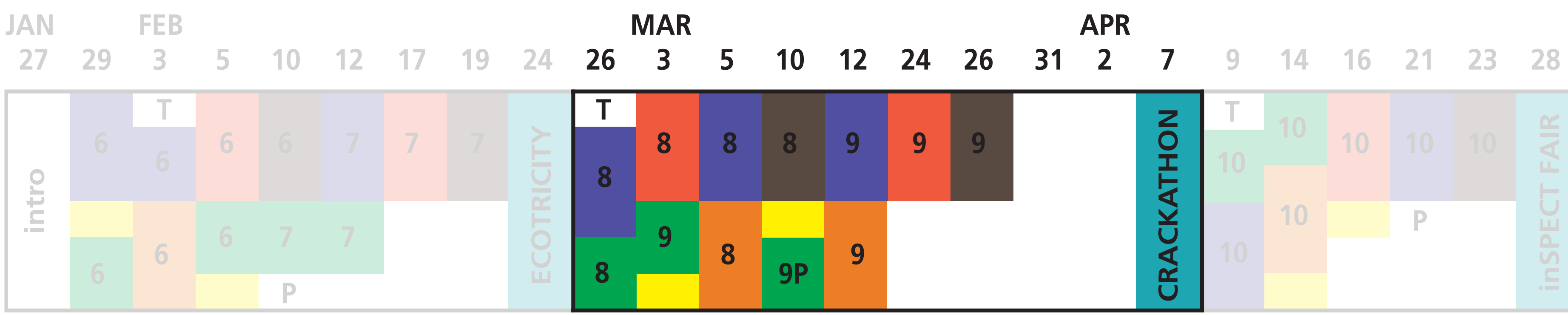
1 design   2 approach

In-class activities



In-class activities

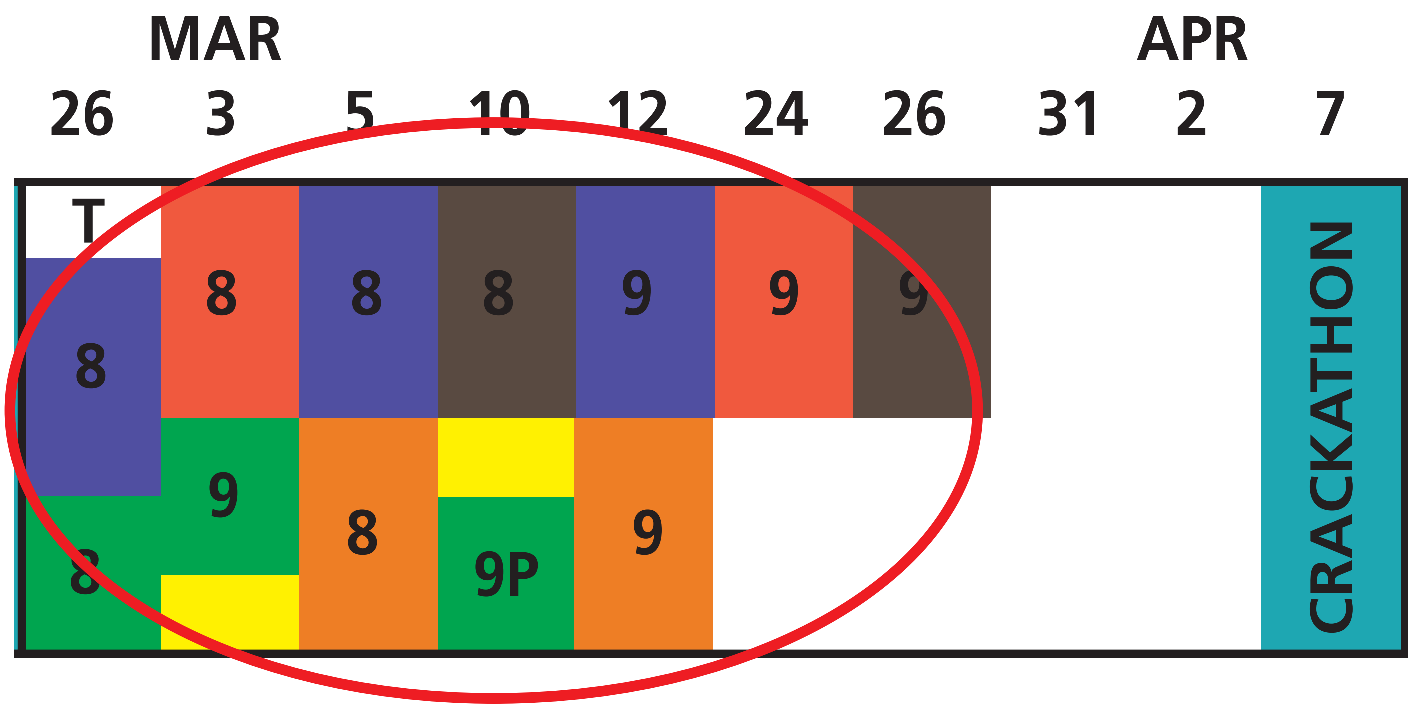
one project



1 design 2 approach

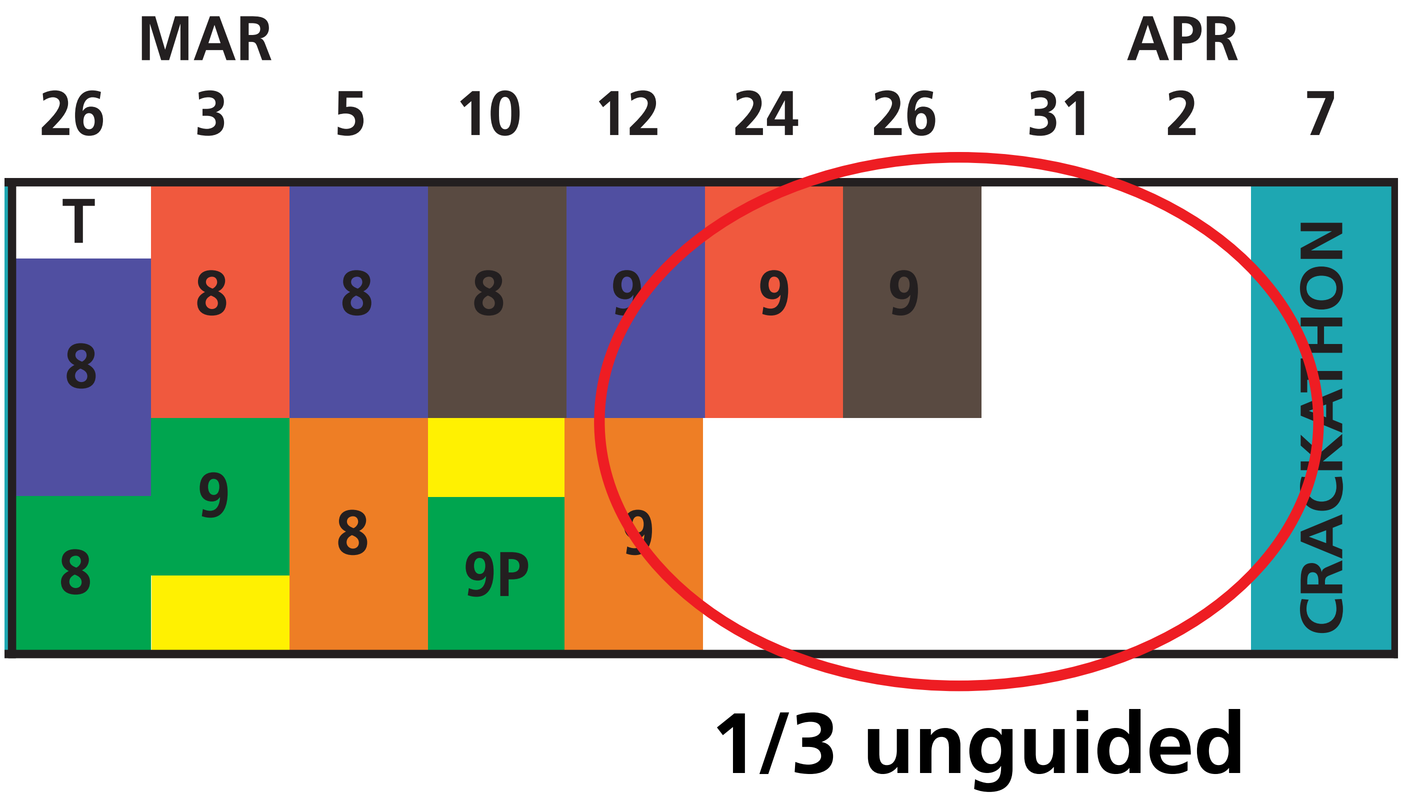
In-class activities

2/3 scaffolded, guided



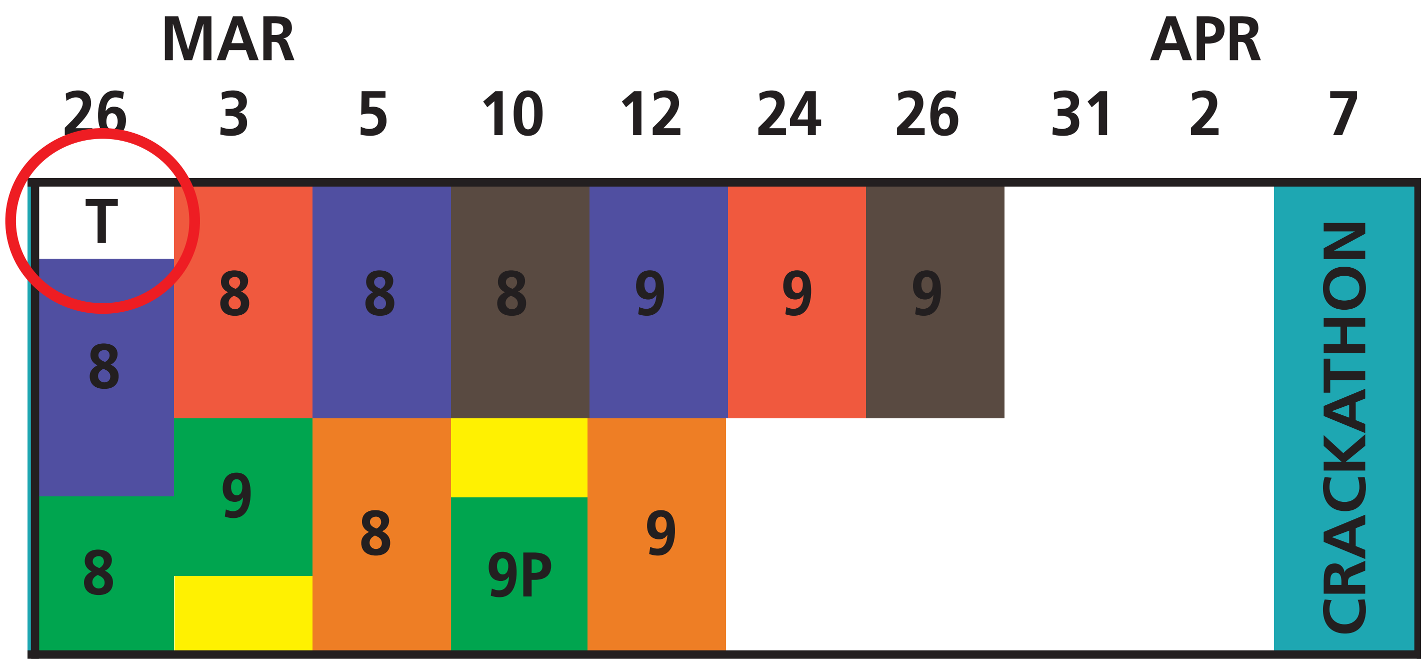
1 design **2** approach

In-class activities



In-class activities

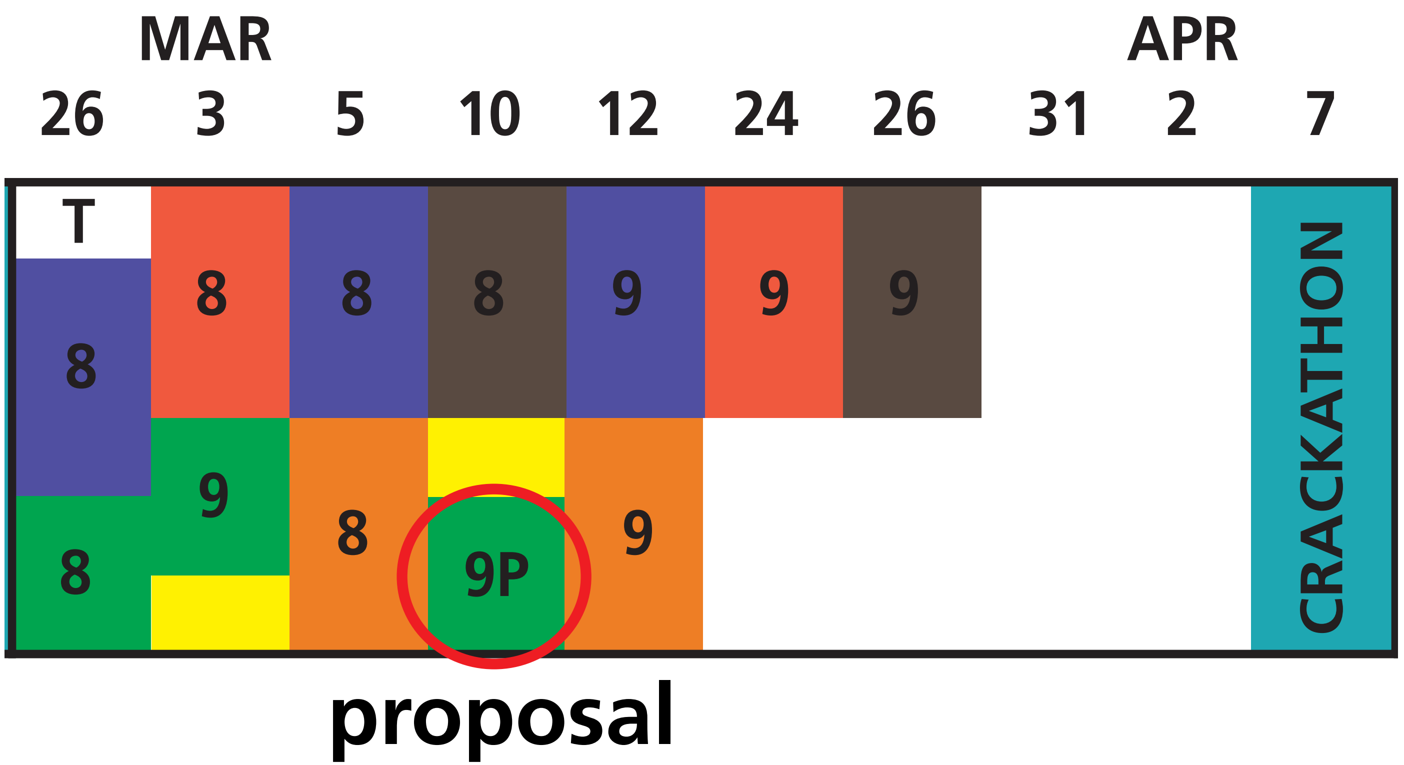
team intro



1 design

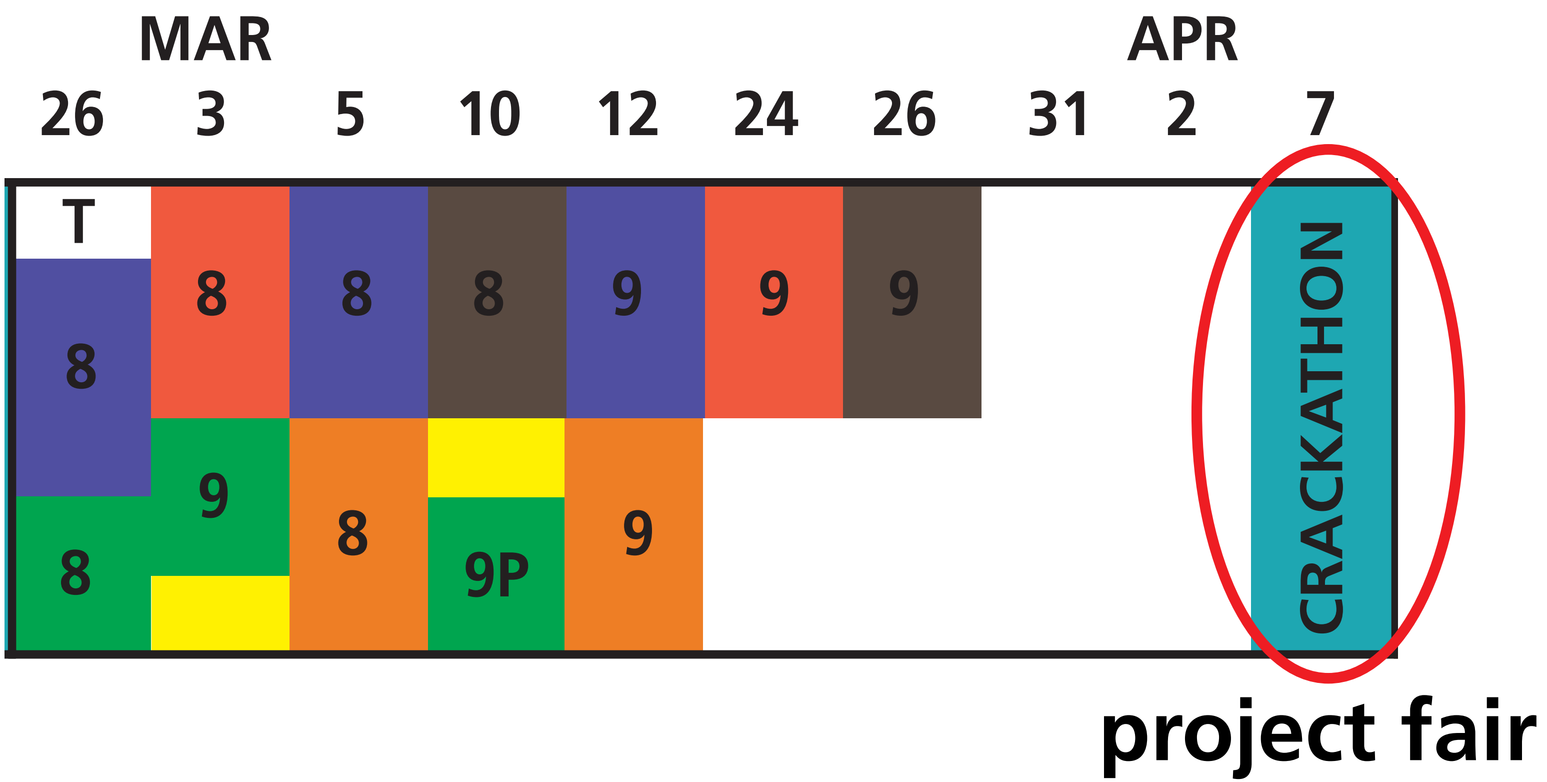
2 approach

In-class activities



1 design **2** approach

In-class activities



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

LC: Learning Catalytics — 90 min

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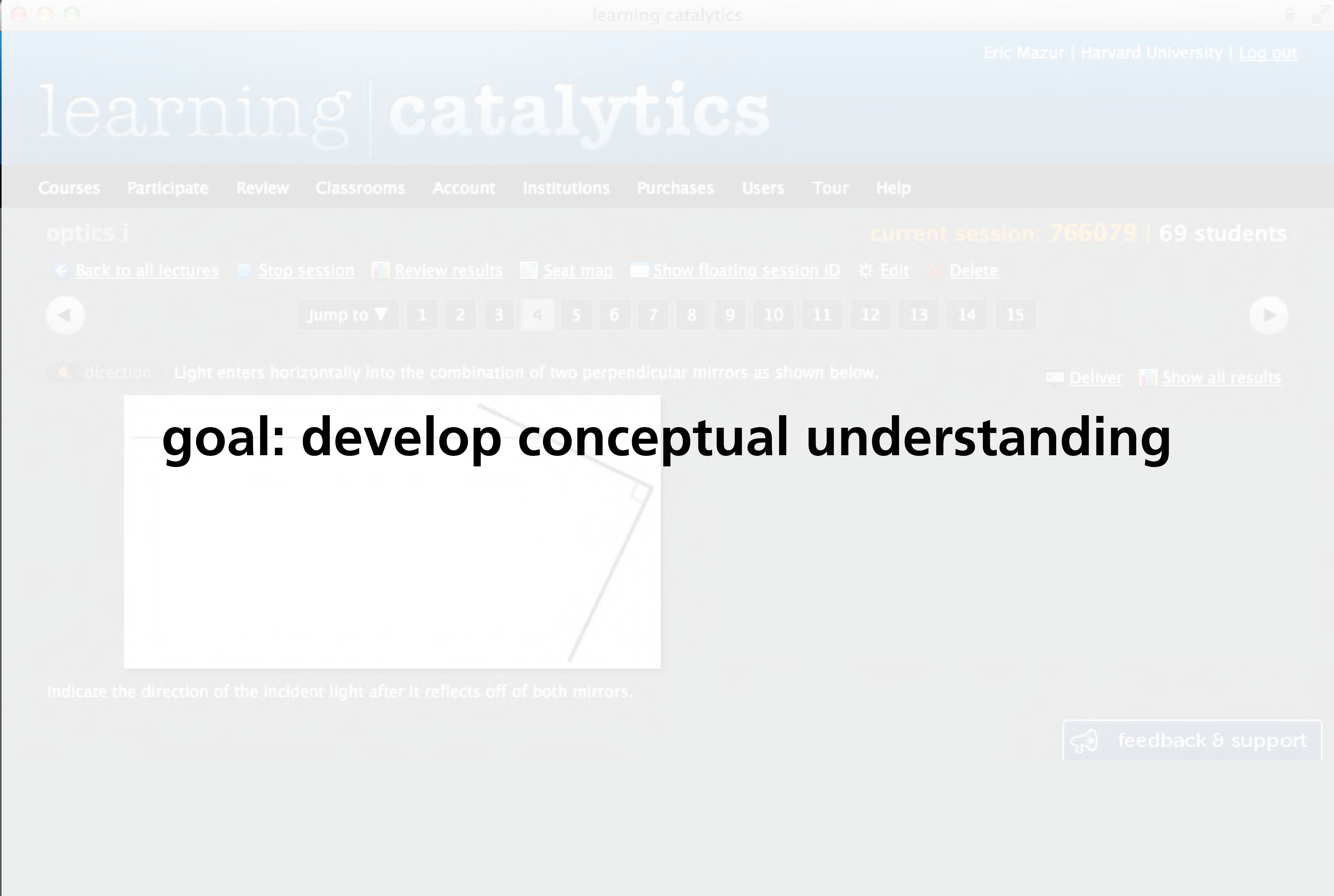
bring device

1 design

2 approach

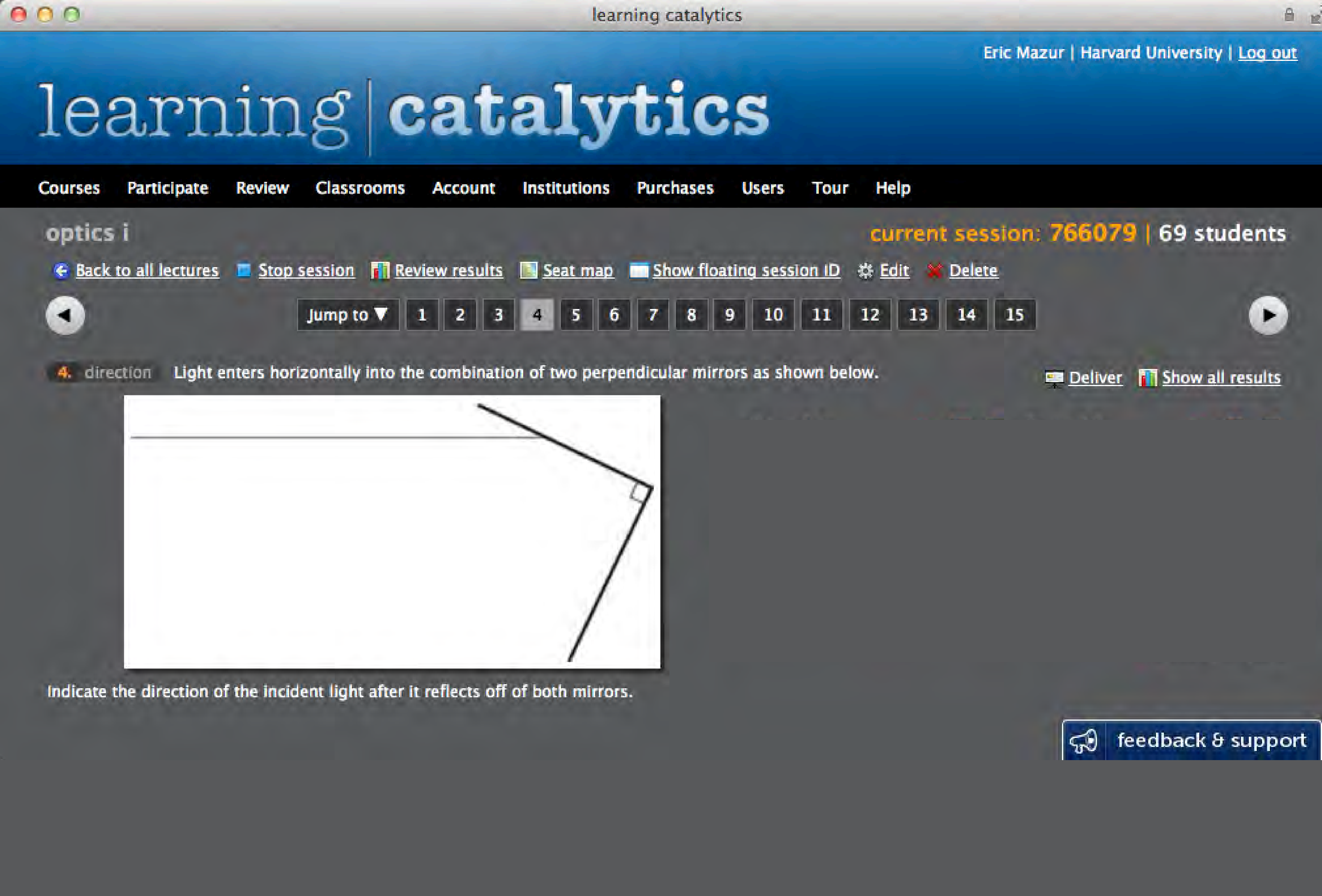


goal: develop conceptual understanding

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



1 design

2 approach

1 design 2 approach

1 design

2 approach

1 design

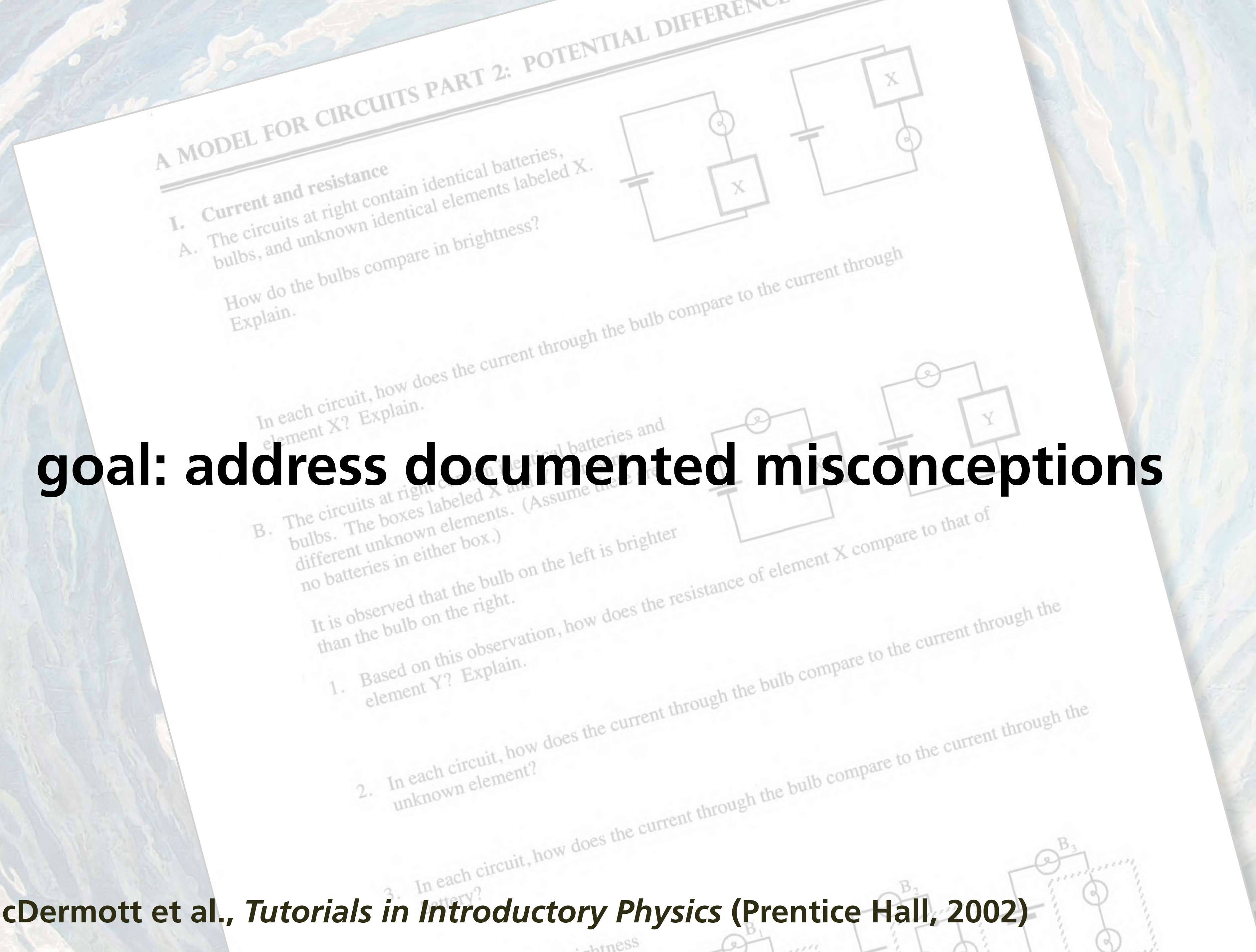
2 approach

1 design

2 approach

In-class activities

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 ... bulbs. The boxes labeled X and ... 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.

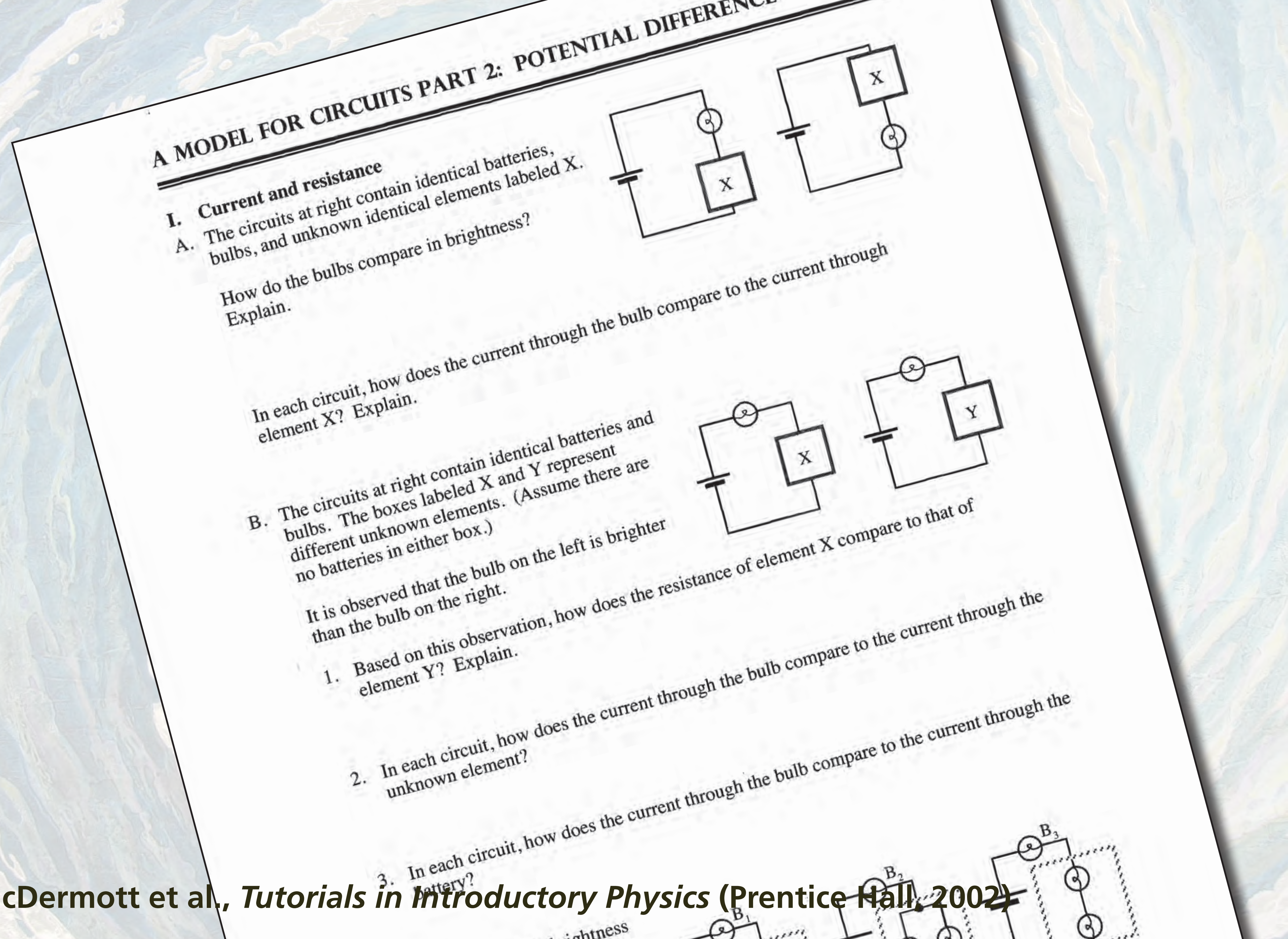
1. Based on this observation, how does the resistance of element X compare to that of element Y? Explain.

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 battery?

goal: address documented misconceptions

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



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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.

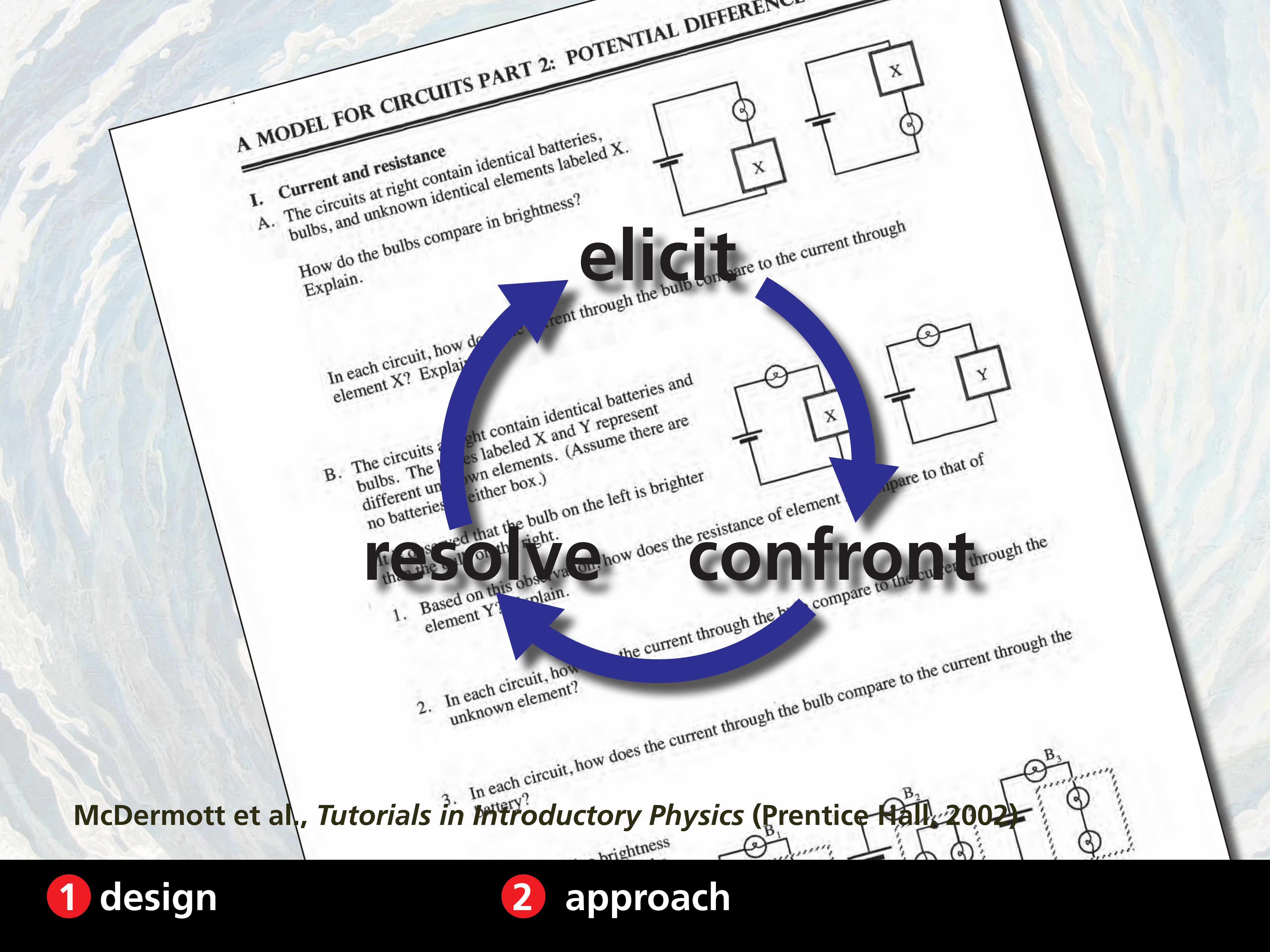
2. In each circuit, how does the current through the bulb compare to the current through the unknown element?

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

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

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.
elicit
confront
resolve
McDermott et al., *Tutorials in Introductory Physics* (Prentice Hall, 2002)
1 design
2 approach

In-class activities

understand

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- Instructor poses question
- Answer alone
- Discuss in team
- Answer again

bring device

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evaluate

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- Part 2: solve with team

bring device

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 [illegible] during the explosive separation of a professional fireworks shell. Answer units: [J]
2. Estimate the relative speed of the moon as seen from an [illegible] the earth. Answer units: [m/s]
3. Estimate the power output by an average person completing a "stadium [illegible]" 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

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!

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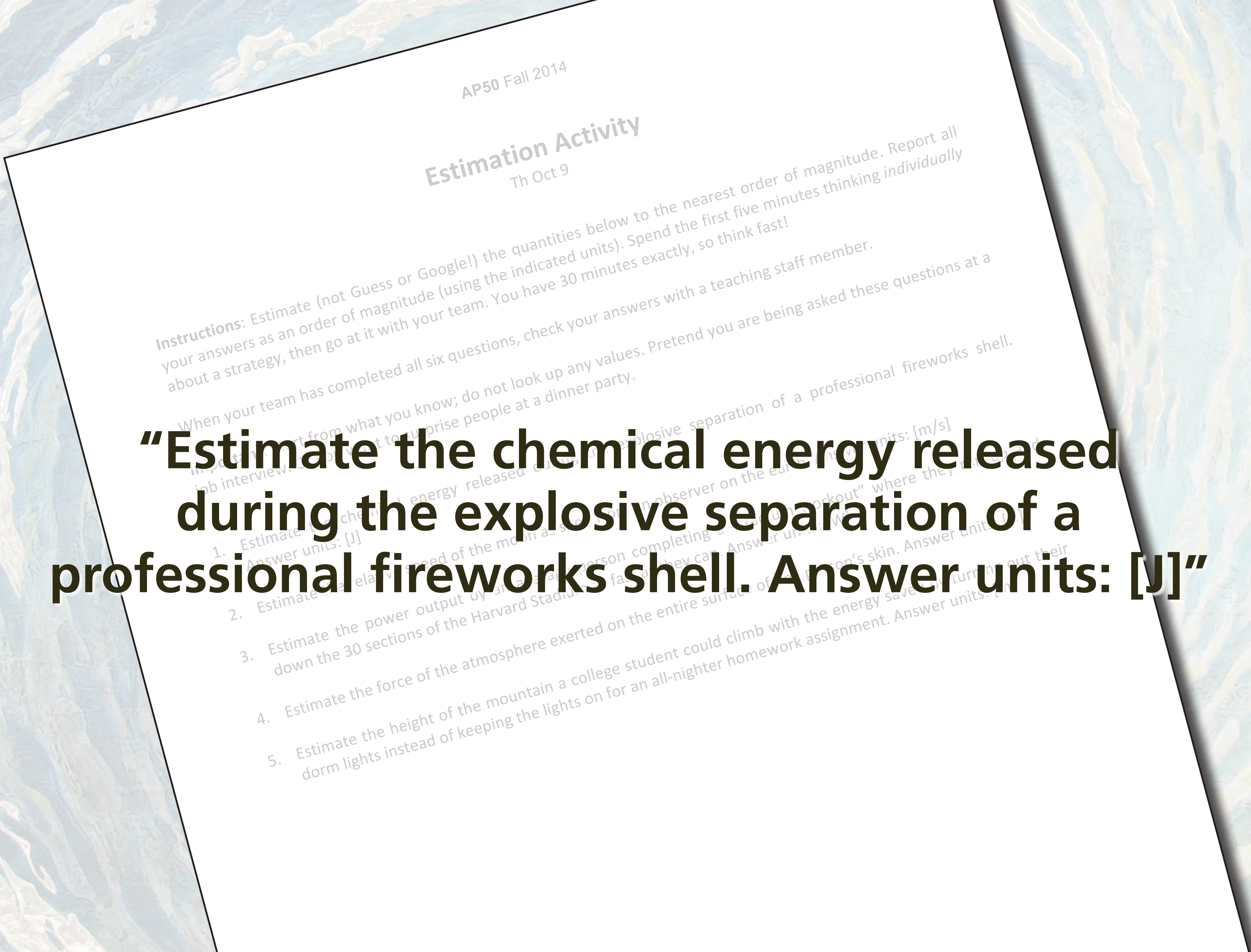
3. Estimate the power output by an average person completing a "stadium workout" where they run up and down the 30 sections of the Harvard Stadium as fast as they can. Answer units: [W]
4. Estimate the force of the atmosphere exerted on the entire surface of one person's skin. Answer units: [N]
5. Estimate 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]

1 design

2 approach



"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

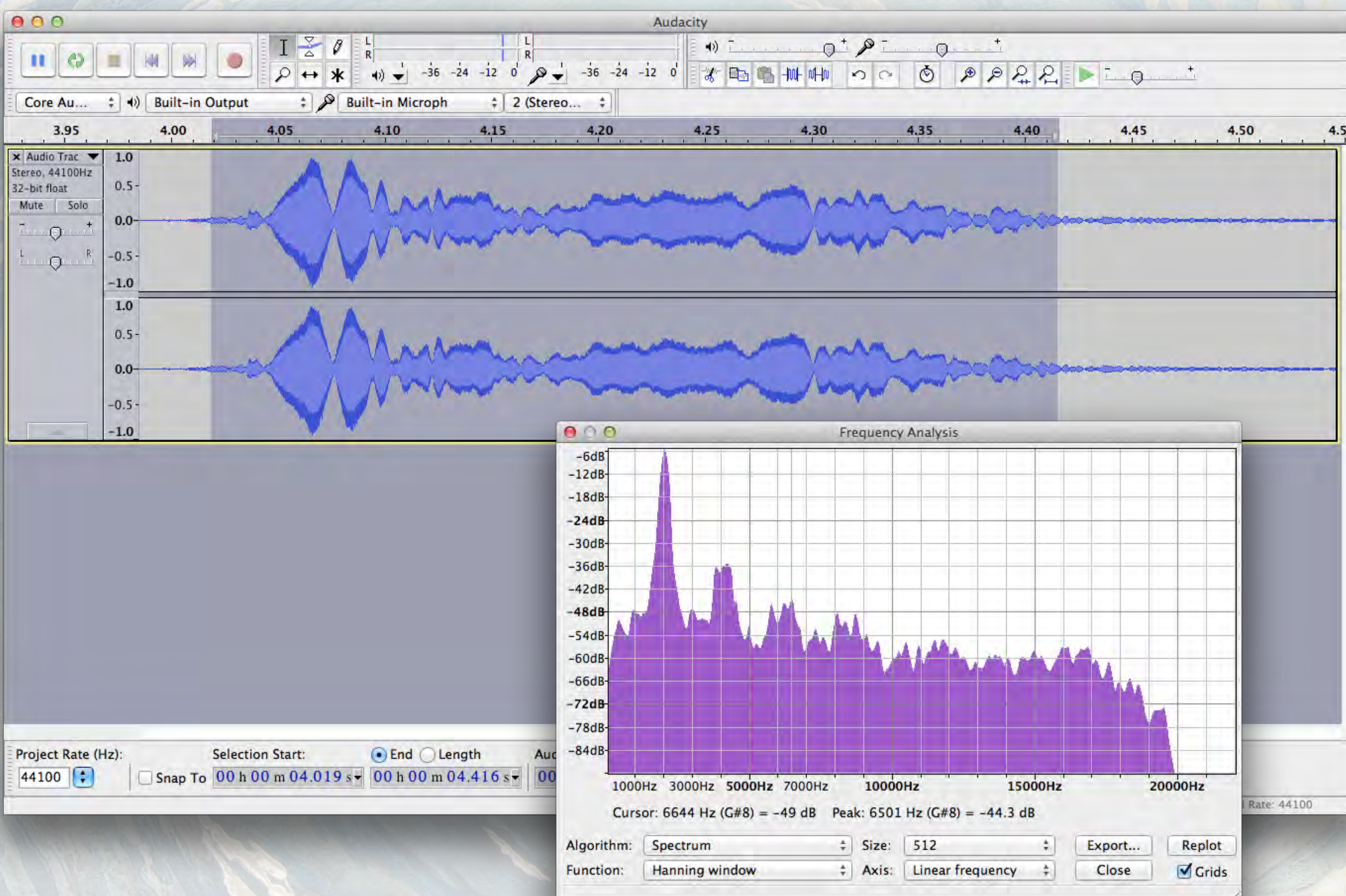
RAA: Readiness Assurance Activity — 90 min
- Part 1: solve problems alone
- Open book, open internet
- Part 2: solve with team

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

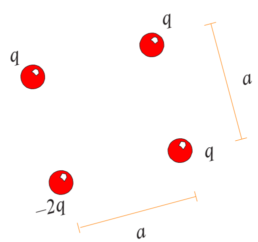
due W Feb 6 in class

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.

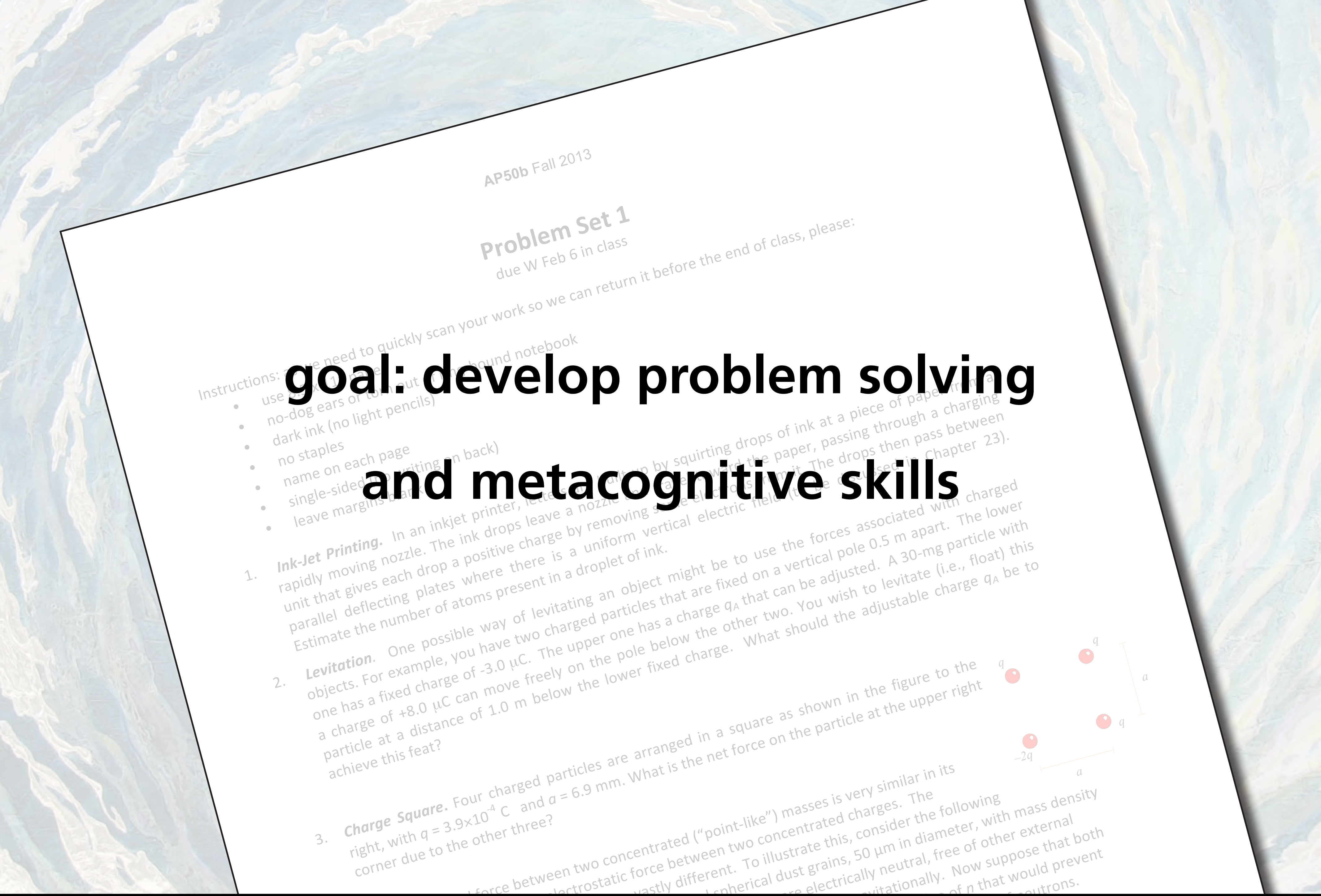
2. ***Levitation***. One possible way of levitating an object might be to use the forces associated with charged objects. For example, you have two charged particles that are fixed on a vertical pole 0.5 m apart. The lower one has a fixed charge of -3.0 μC. The upper one has a charge q_A that can be 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 ...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 ...re electrically neutral, free of other external ...vitationally. Now suppose that both ...e of n that would prevent ...f 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

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. D... stage, you may only use **red ink** to write on your problem sets (pens will be provided in cla... 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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You can consult the textbook and online resources, and you may consult the teaching sta

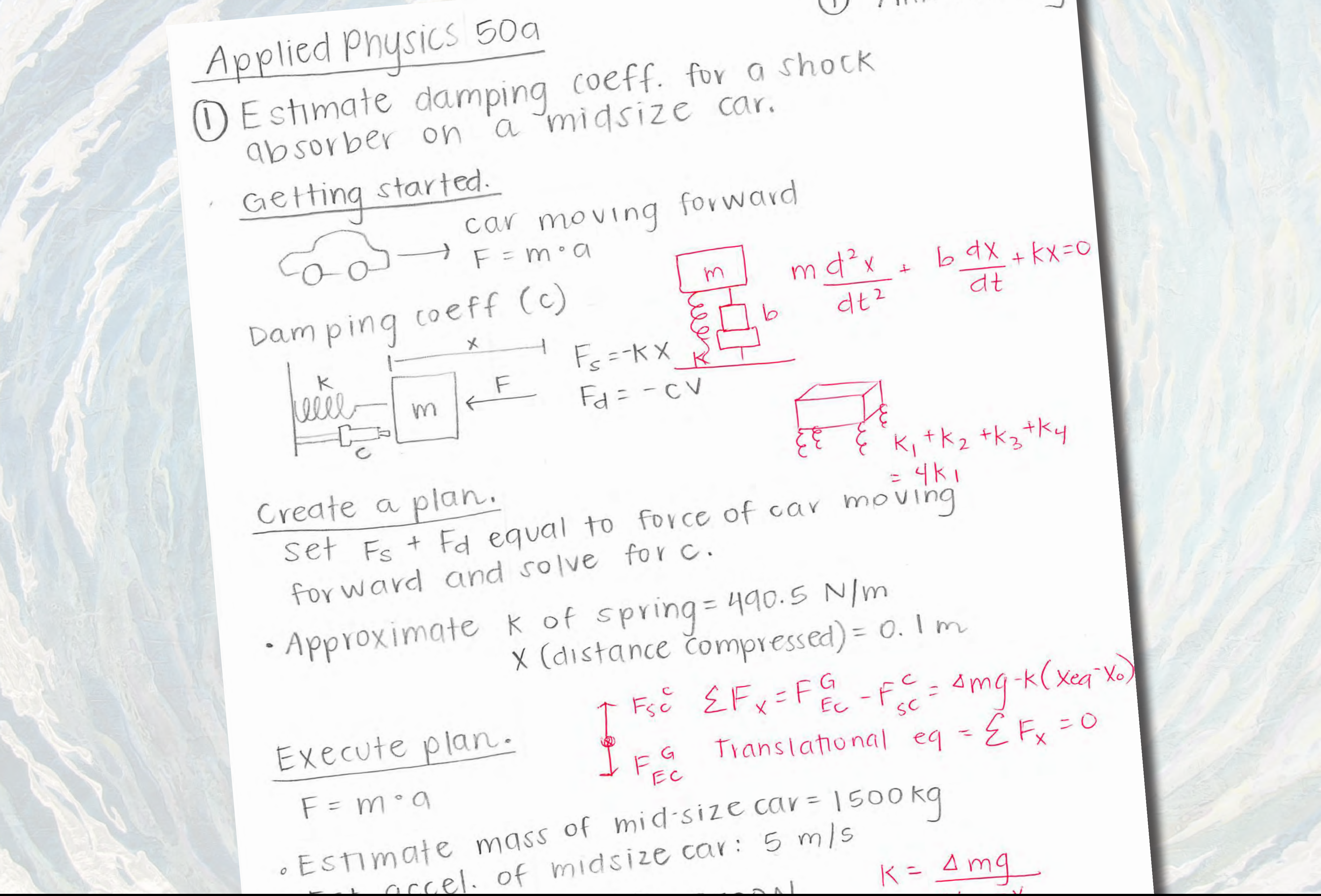
at home:

implement 4-step procedure

(evaluated on effort)

1 design

2 approach



1 **design**

2 **approach**

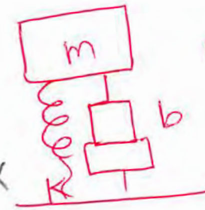
Applied Physics 50a

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

Getting started.

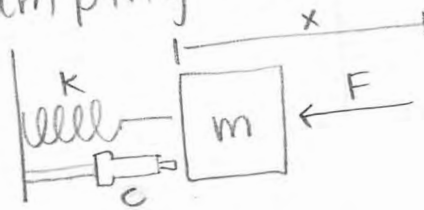
car moving forward

$F = m \cdot a$



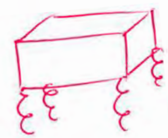
$m \frac{d^2x}{dt^2} + b \frac{dx}{dt} + kx = 0$

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

F_{SC}^{C} $\quad \Sigma F_x = F_{EC}^{G} - F_{SC}^{C} = \Delta mg - k(x_{eq} - x_0)$

F_{EC}^{G} $\quad$ Translational eq $= \Sigma F_x = 0$

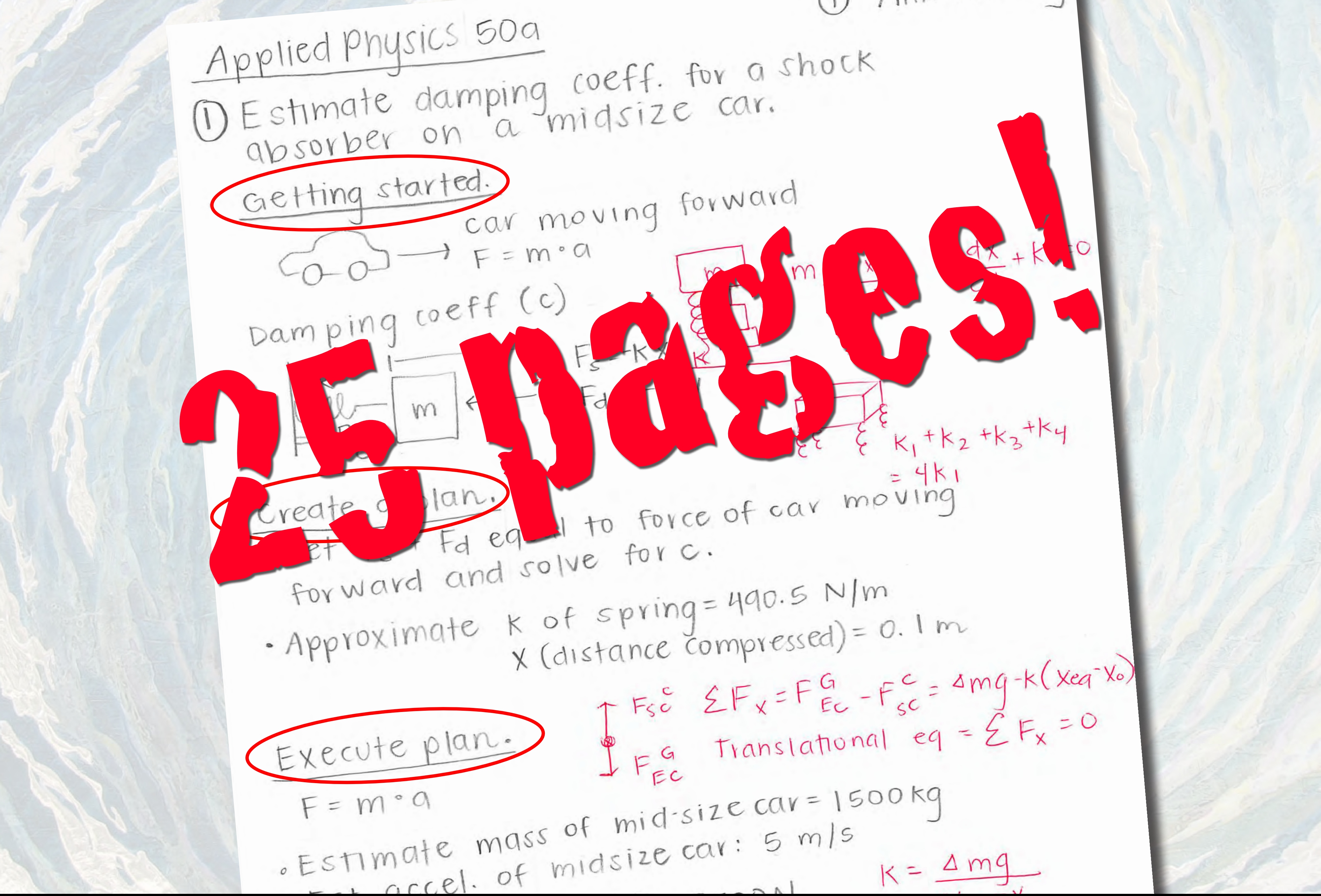
Execute plan.

$F = m \cdot a$

- 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

$F = m \cdot a$

Damping coeff (c)

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

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

$\Sigma F_x = F^G_{Ec} - F^c_{sc} = \Delta mg - k(x_{eq} - x_0)$

Translational eq $= \Sigma F_x = 0$

Execute plan.

$F = m \cdot a$

• Estimate mass of mid-size car = 1500 kg

Est. accel. of midsize car: 5 m/s

$K = \frac{\Delta mg}{}$

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

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

in class:

mark up/improve solutions

complete reflection sheet

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 1 ½ 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

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

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

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

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

↳ $f = \frac{v}{\lambda}$

• $\lambda = \frac{v}{f} = \frac{200}{4}$ (~~0.5π~~ / ~~¼~~) = 4 cm

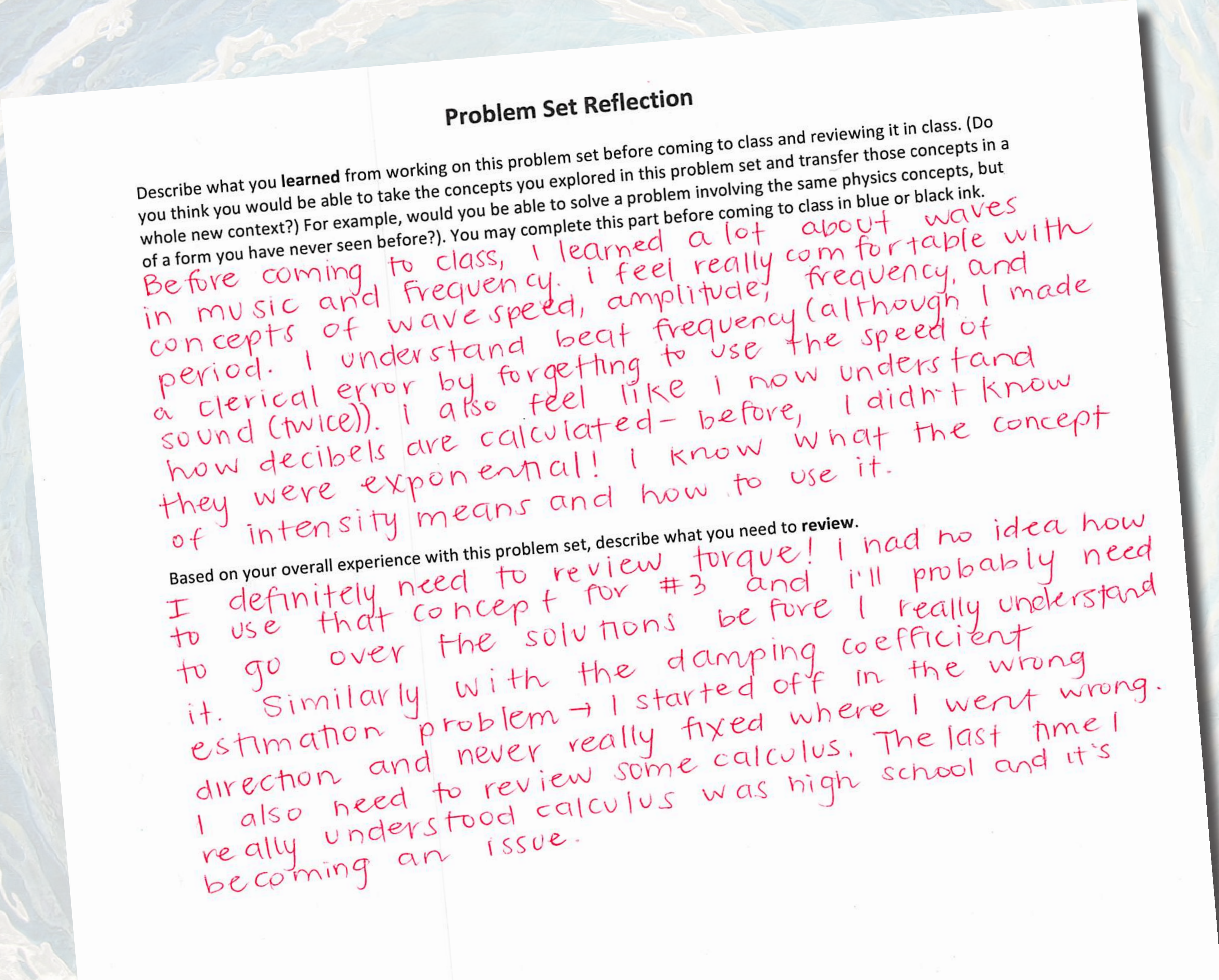
$= \frac{200}{4} = 50$

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

(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

goal: formative assessment

collaborative learning

❶ design ❷ approach

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

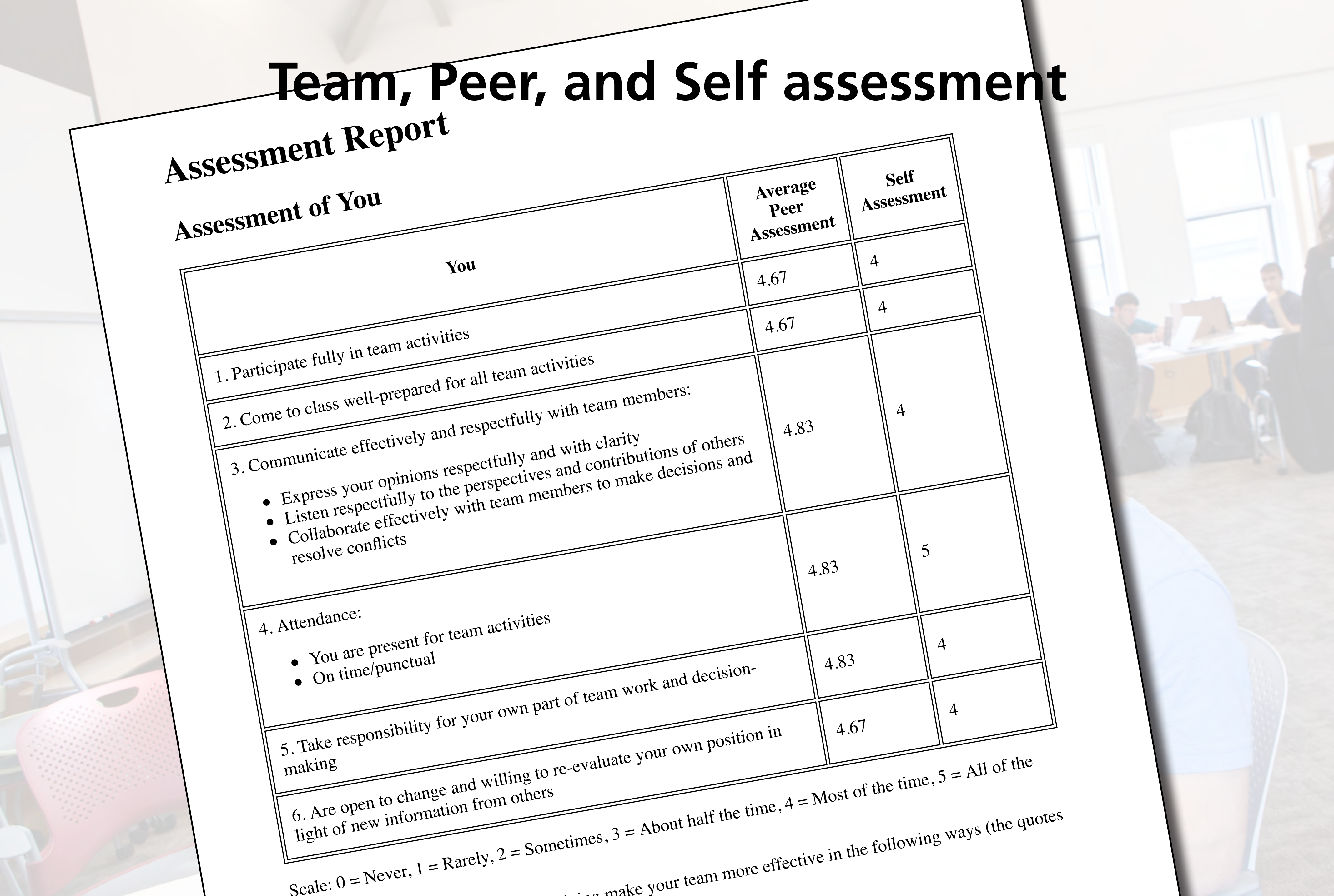
4. Relative contributions

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

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

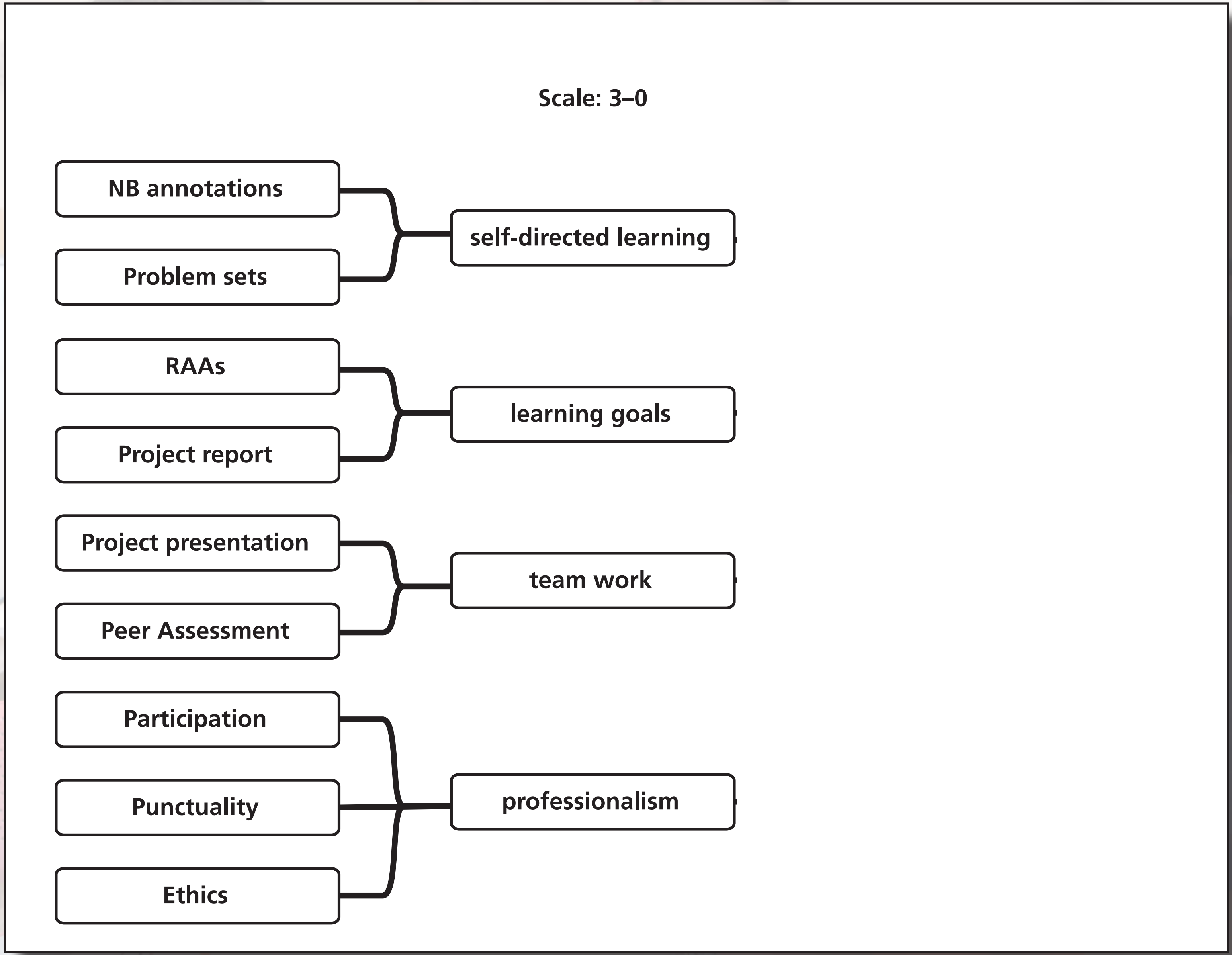
self-directed learning

learning goals

team work

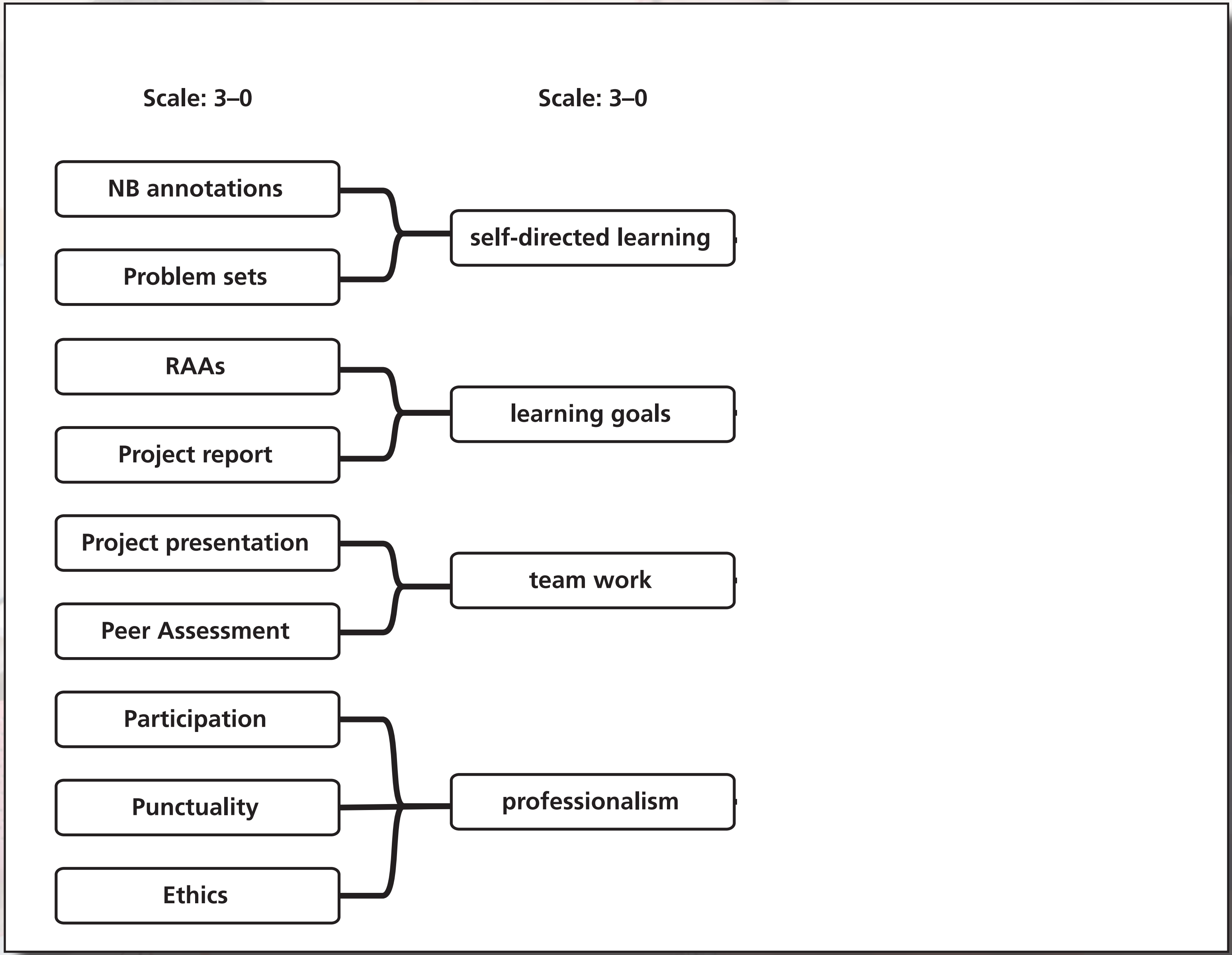
professionalism

Assessment



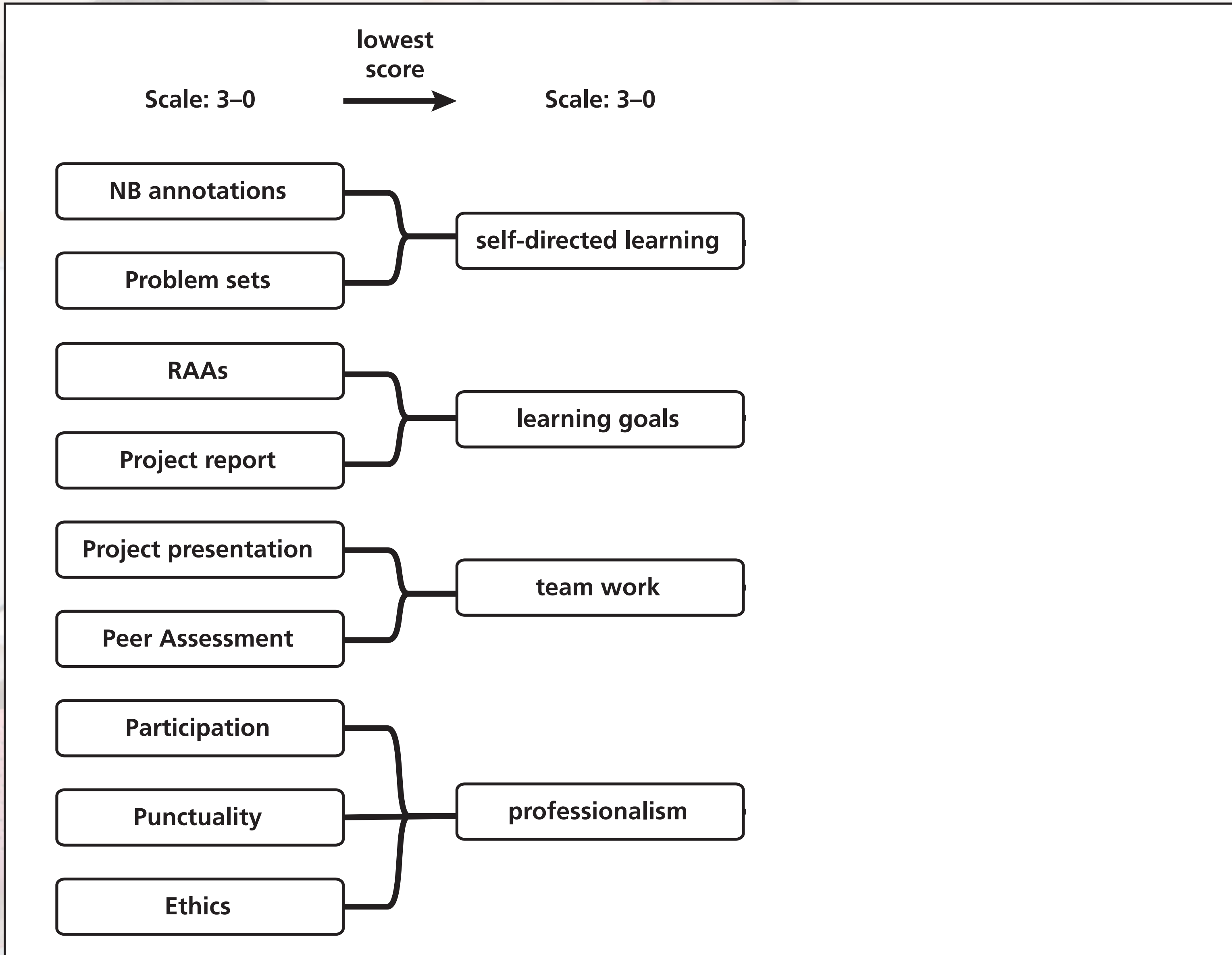
1 design 2 approach

Assessment



❶ design ❷ approach

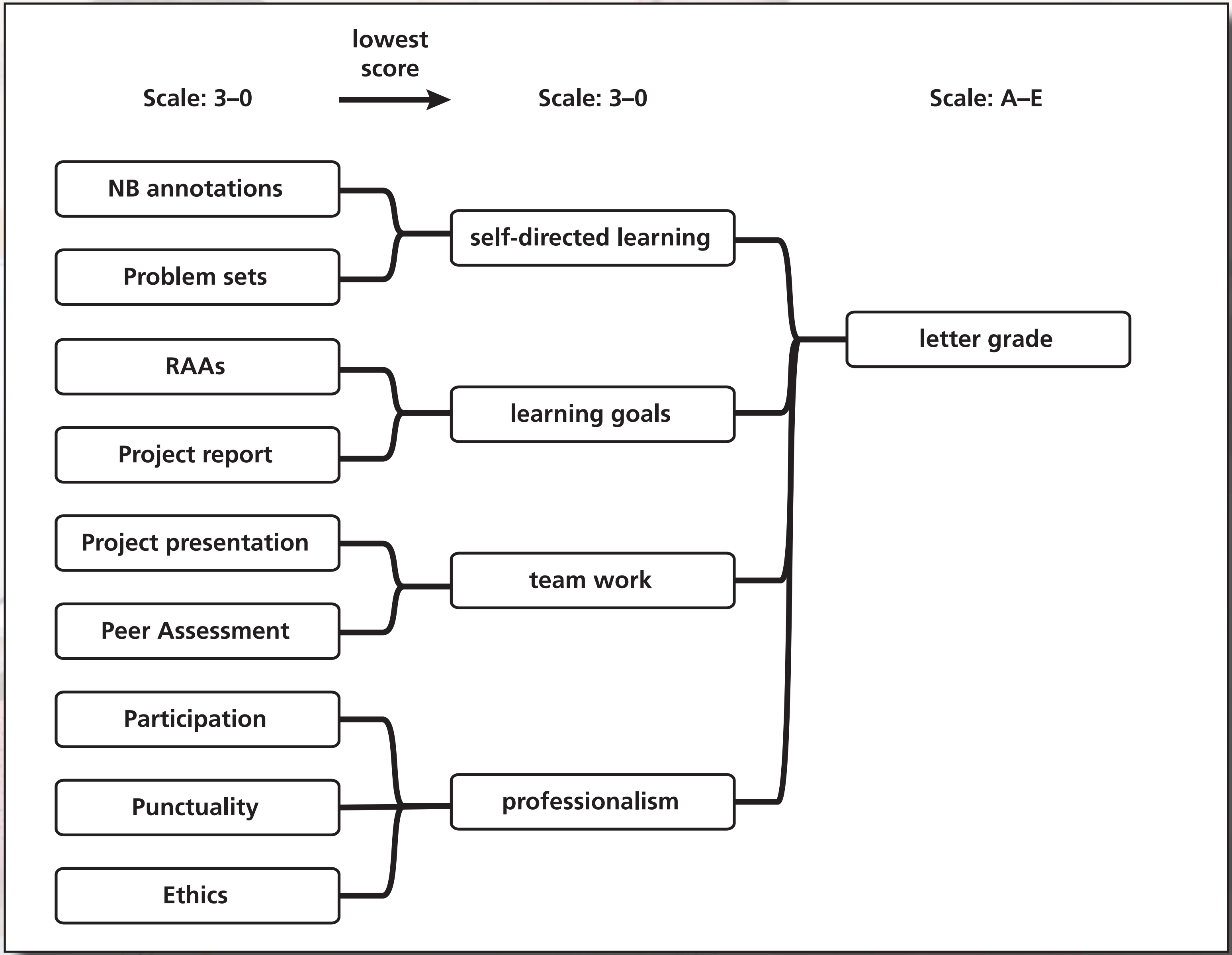
Assessment



1 design

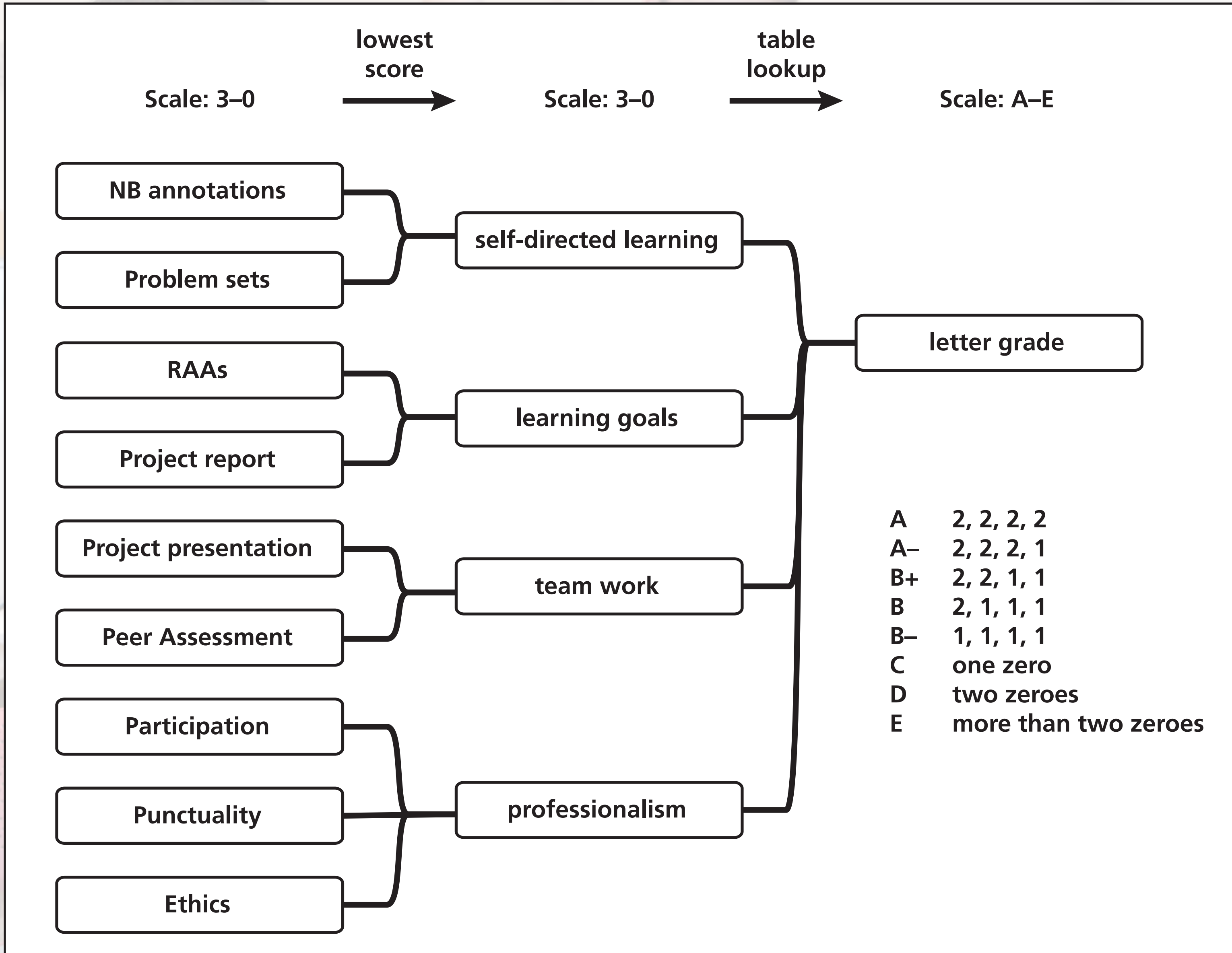
2 approach

Assessment



1 design 2 approach

Assessment



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 read- ings 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."

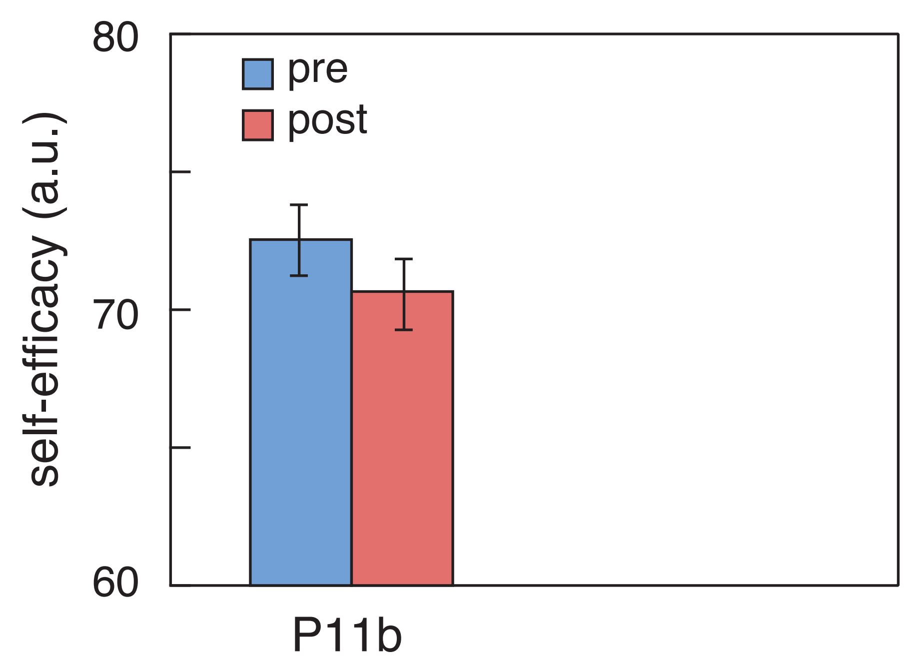
(via email)

Self-efficacy

Self-efficacy

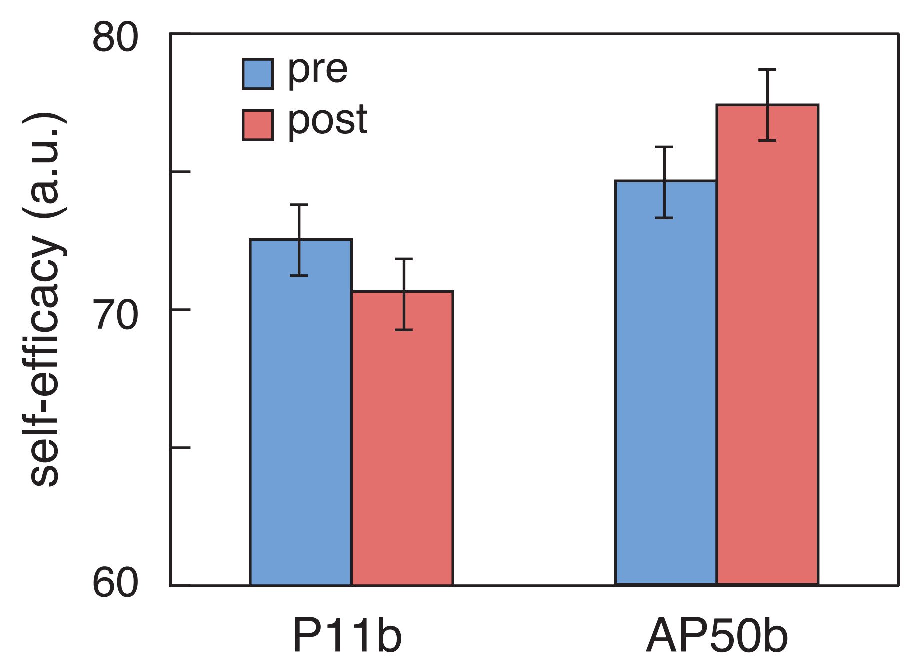
(students' belief in their ability to succeed)

Self-efficacy



1 design
2 approach
3 results

Self-efficacy



1 design 2 approach 3 results

Self-directed learning

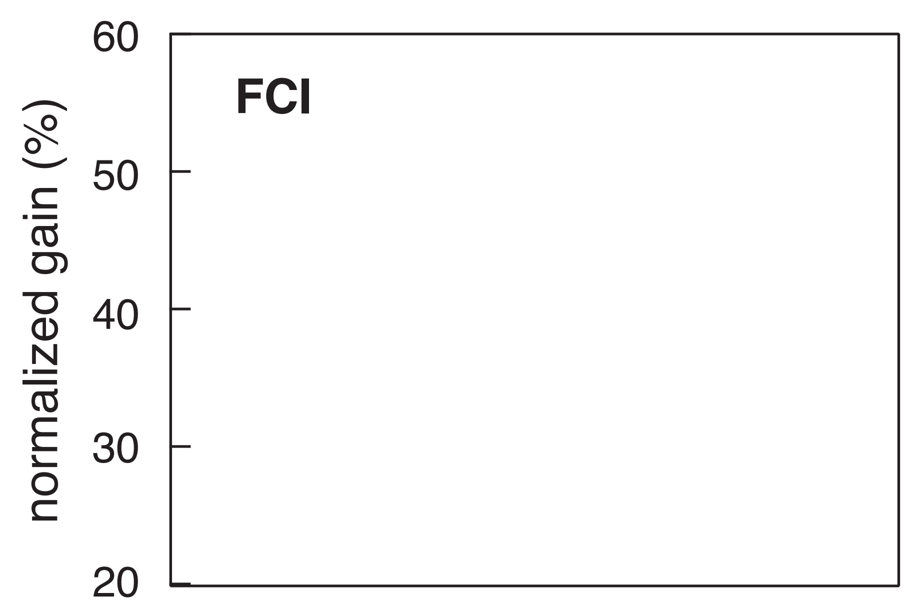
1 design　　2 approach　　3 results

Self-directed learning

NB data shows:

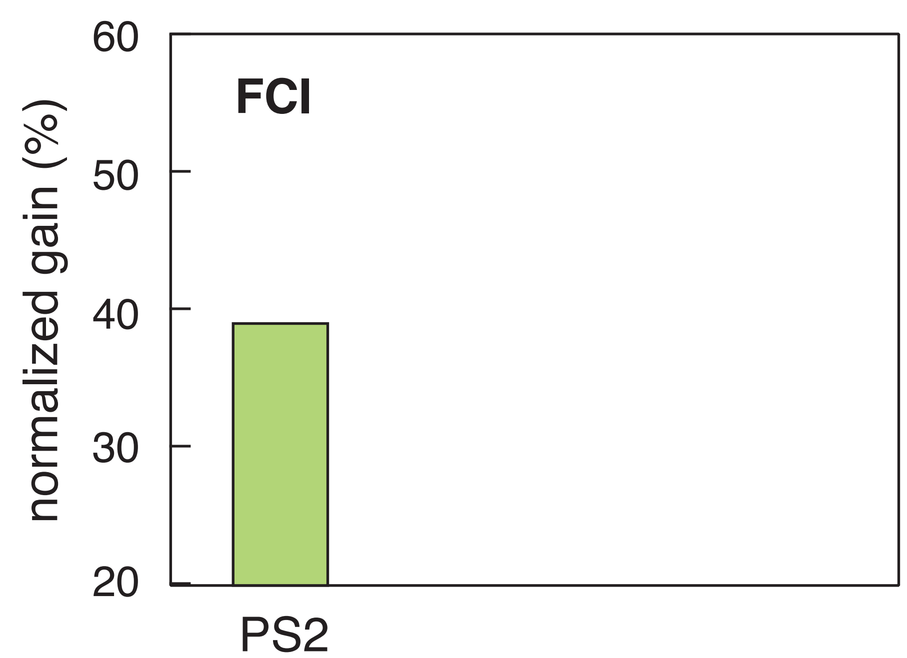
- student spend on average 2.3 hrs/chapter
- 600–700 annotations/chapter (8–10/stu)

Conceptual Mastery



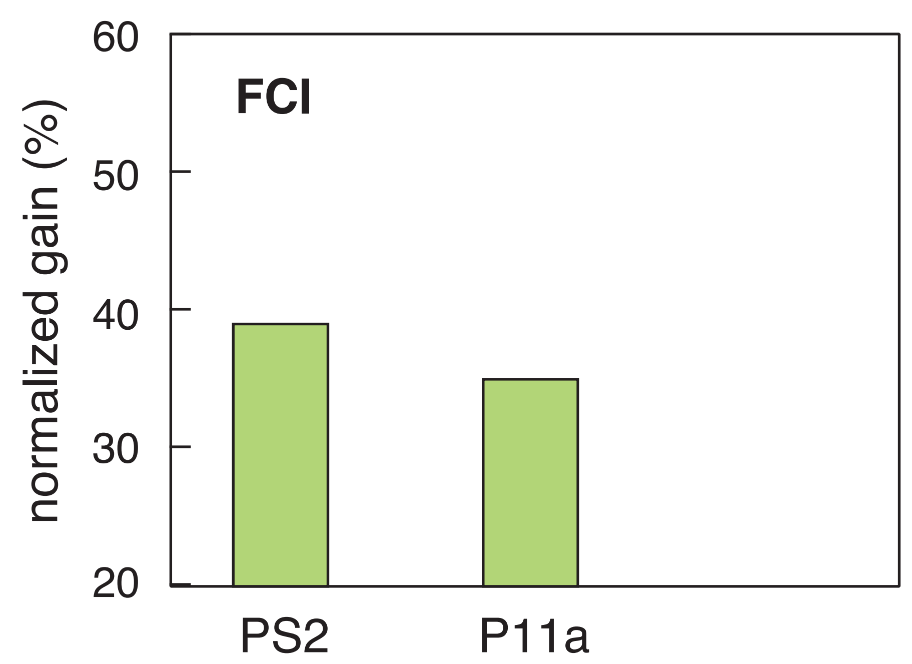
1 design 2 approach 3 results

Conceptual Mastery



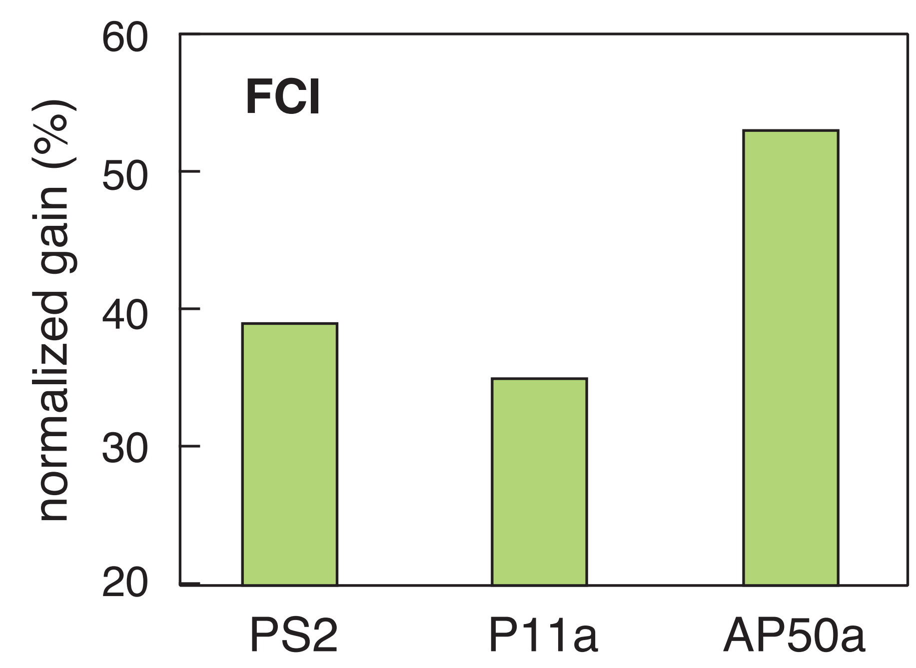
1 design 2 approach 3 results

Conceptual Mastery



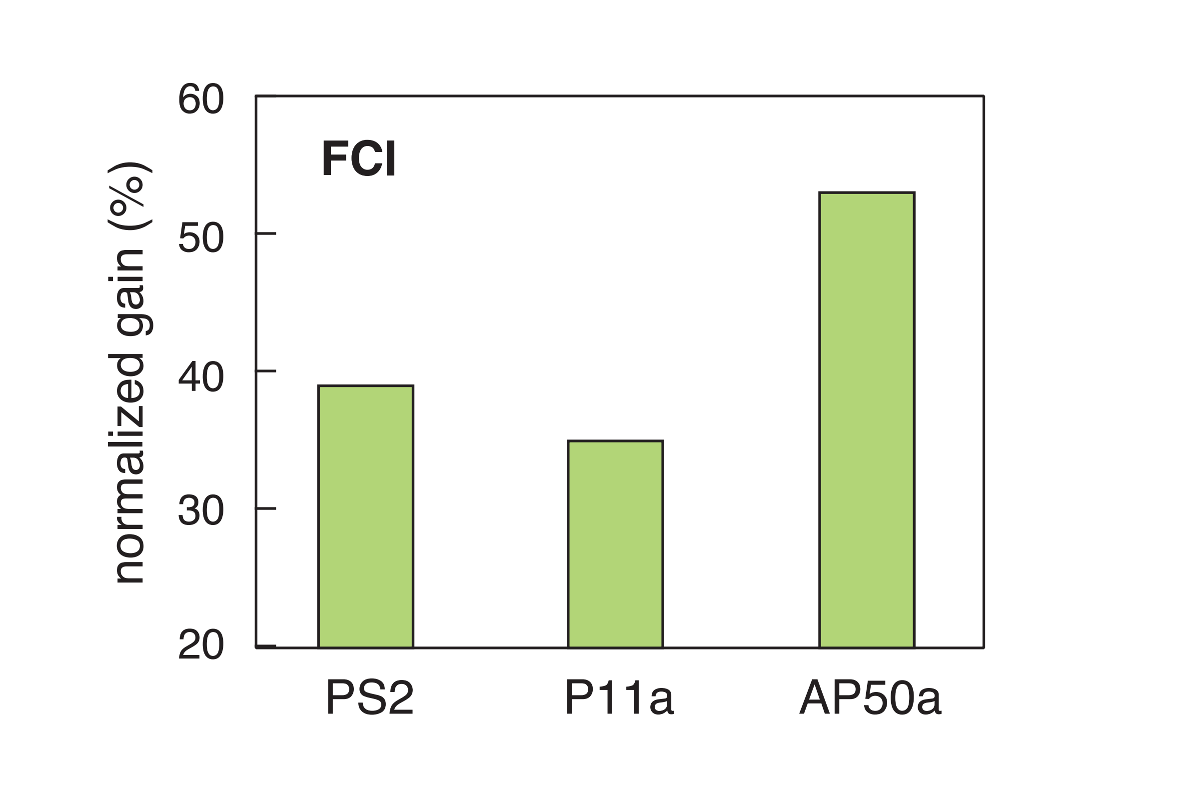
1 design
2 approach
3 results

Conceptual Mastery



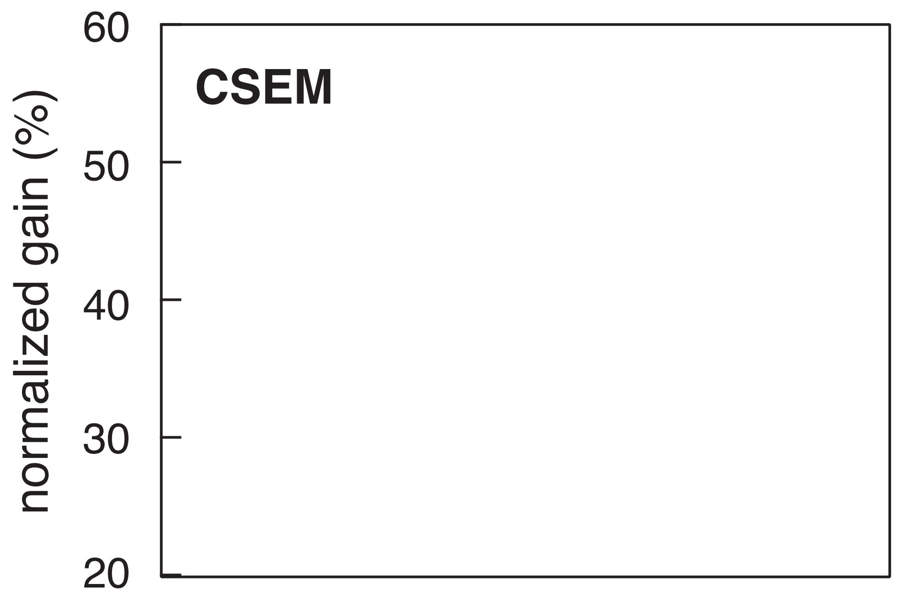
1 design
2 approach
3 results

Conceptual Mastery

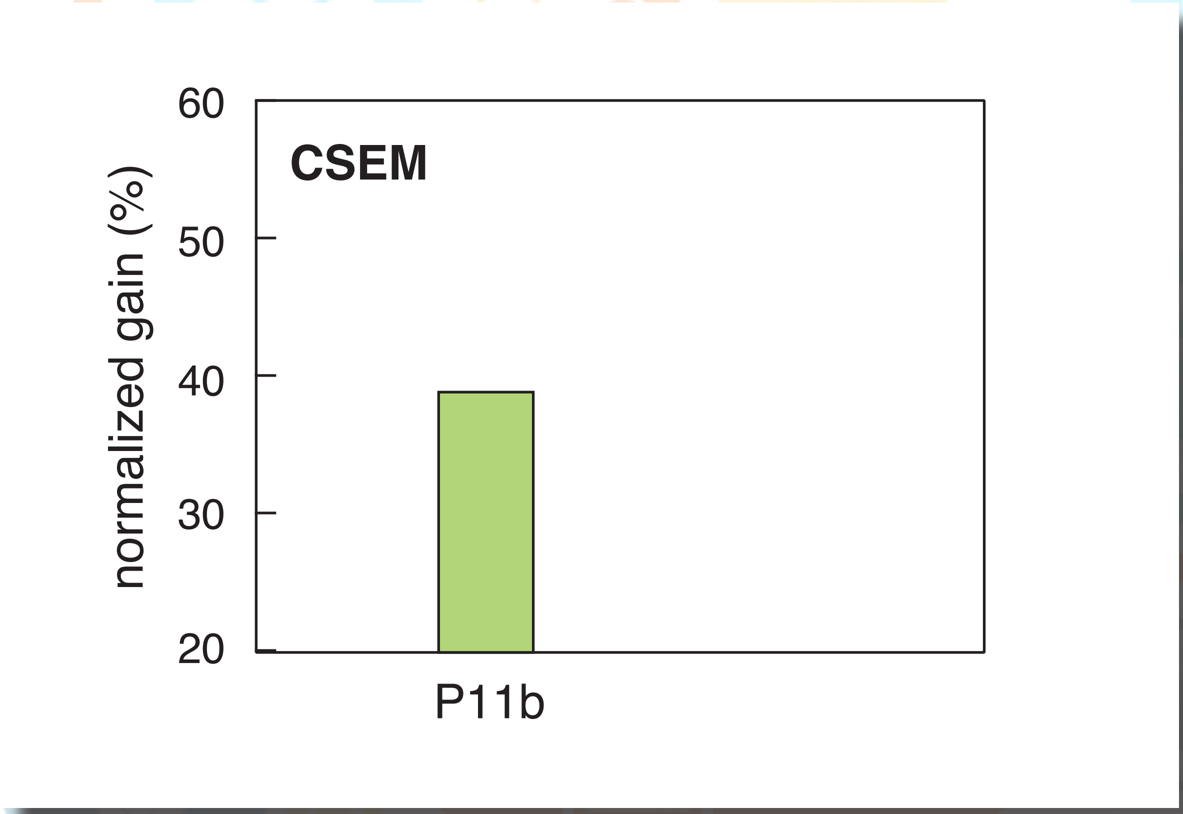


largest conceptual gain in *any* course past 6 yrs!

Conceptual Mastery

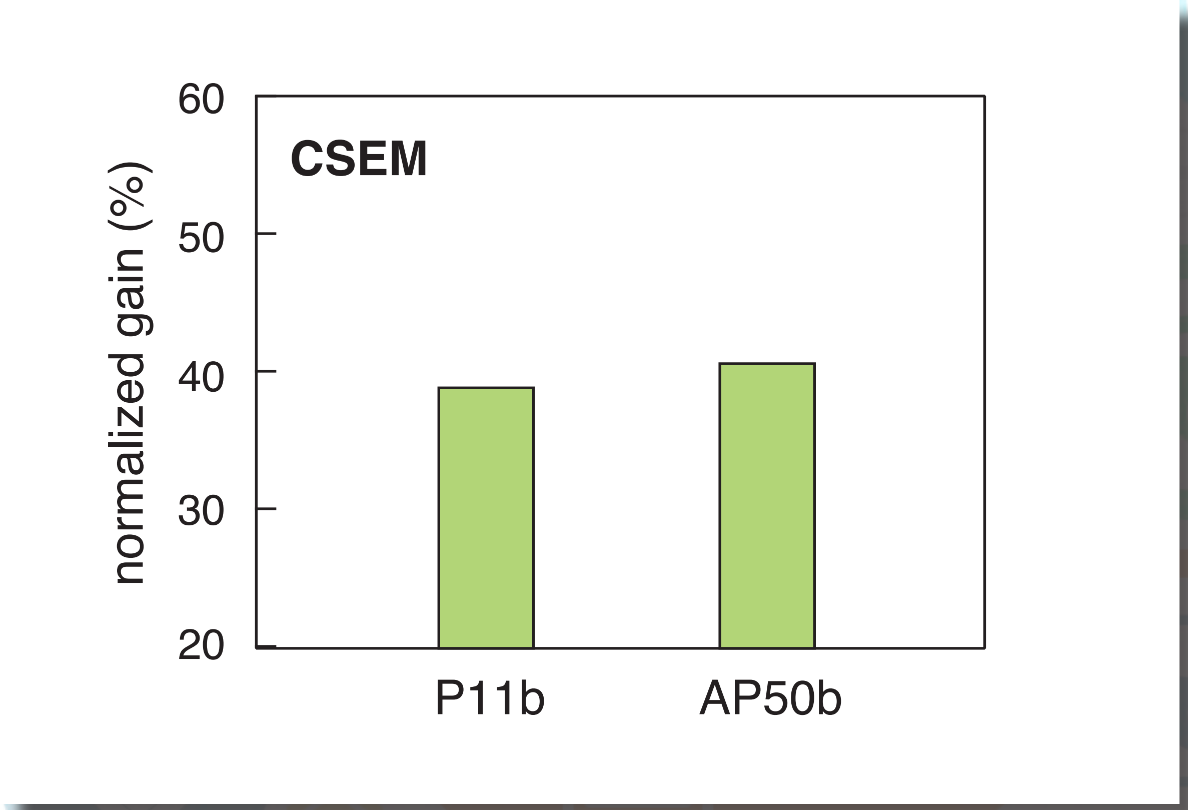


Conceptual Mastery



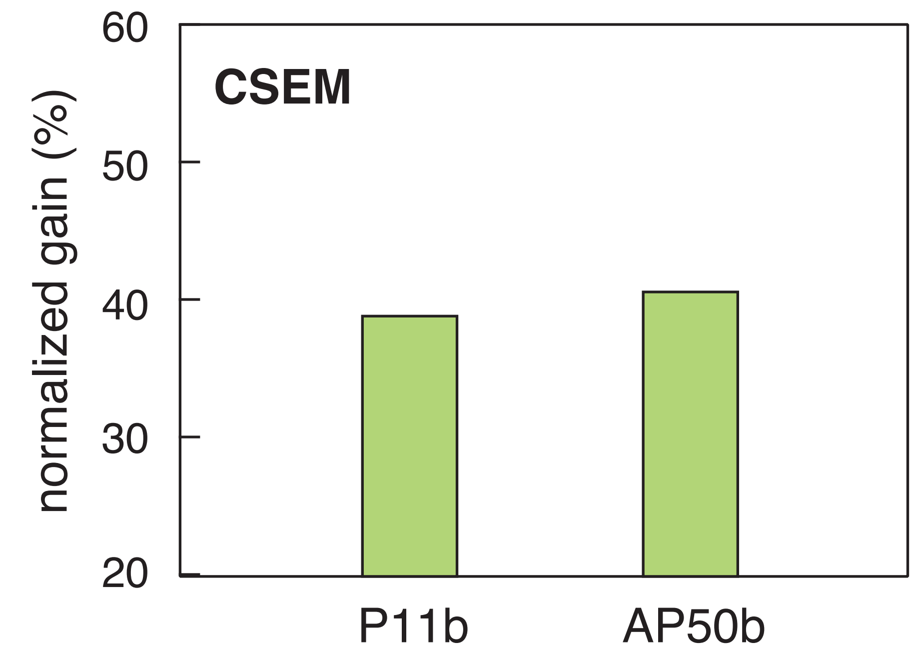
1 design 2 approach 3 results

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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