Innovating education to educate innovators

MAZUR GROUP

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Joint 13th APPC and 22nd AIP Congress
Brisbane, Australia, 5 December 2016

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The Optical Society

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AUSTRALIAN OPTICAL SOCIETY

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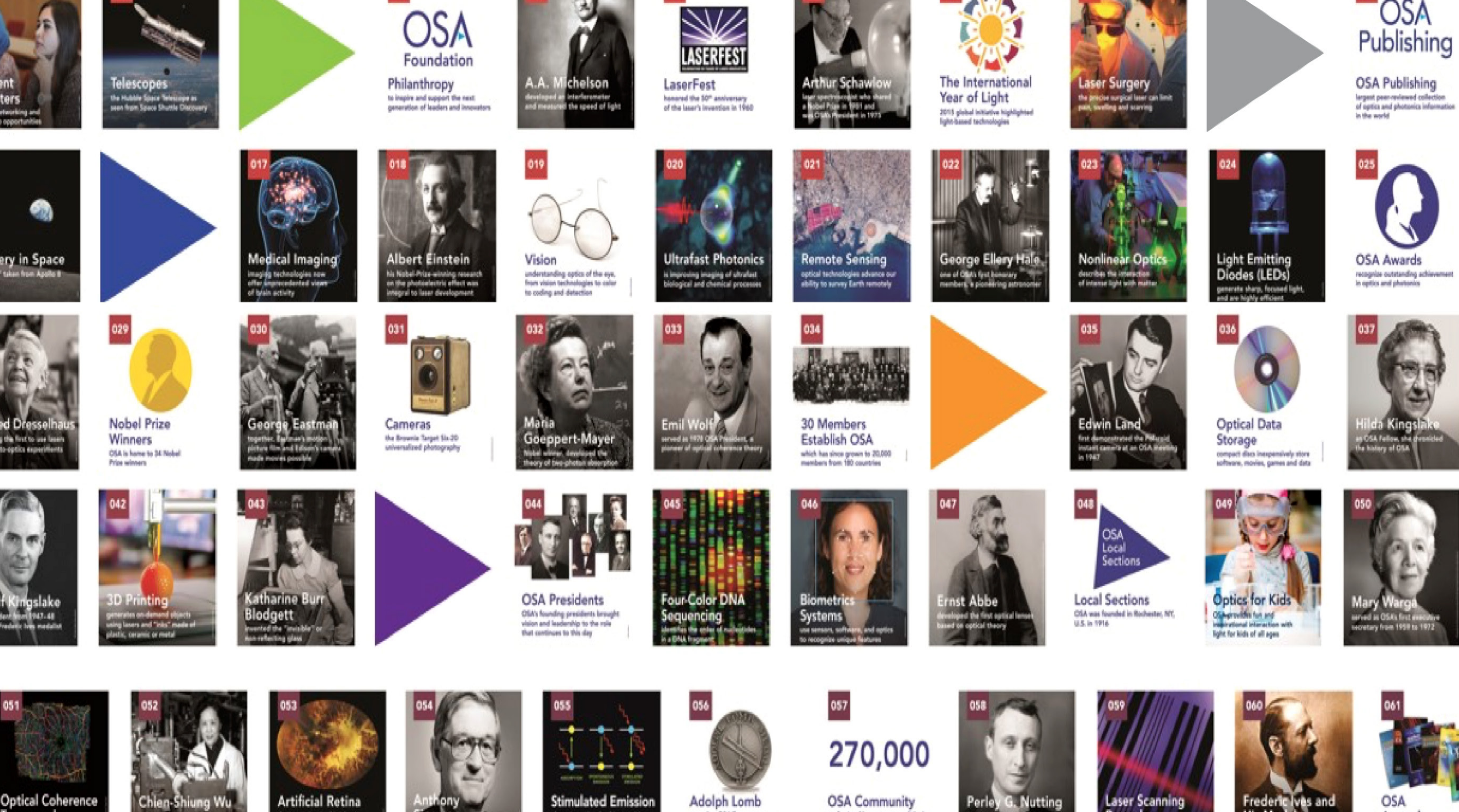
Telescopes
the Hubble Space Telescope as seen from Space Shuttle Discovery
OSA Foundation
Philanthropy
to inspire and support the next generation of leaders and innovators
A.A. Michelson
developed an interferometer and measured the speed of light
LASERFEST
LaserFest
honored the 50th anniversary of the laser's invention in 1960
Arthur Schawlow
laser spectroscopist who shared a Nobel Prize in 1981 and was OSA's President in 1975
The International Year of Light
2015 global initiative highlighted light-based technologies
Laser Surgery
the precise surgical laser can limit pain, swelling and scarring
OSA Publishing
OSA Publishing
largest peer-reviewed collection of optics and photonics information in the world
017
Medical Imaging
imaging technologies now offer unprecedented views of brain activity
018
Albert Einstein
his Nobel-Prize-winning research on the photoelectric effect was integral to laser development
019
Vision
understanding optics of the eye, from vision technologies to color to coding and detection
020
Ultrafast Photonics
is improving imaging of ultrafast biological and chemical processes
021
Remote Sensing
optical technologies advance our ability to survey Earth remotely
022
George Ellery Hale
one of OSA's first honorary members, a pioneering astronomer
023
Nonlinear Optics
describes the interaction of intense light with matter
024
Light Emitting Diodes (LEDs)
generate sharp, focused light, and are highly efficient
025
OSA Awards
recognize outstanding achievement in optics and photonics
029
Nobel Prize Winners
OSA is home to 34 Nobel Prize winners
030
George Eastman
together, Eastman's motion picture film and Edison's camera made movies possible
031
Cameras
the Brownie Target Six-20 universalized photography
032
Maria Goeppert-Mayer
Nobel winner, developed the theory of two-photon absorption
033
Emil Wolf
served as 1978 OSA President, a pioneer of optical coherence theory
034
30 Members Establish OSA
which has since grown to 20,000 members from 180 countries
035
Edwin Land
first demonstrated the Polaroid instant camera at an OSA meeting in 1947
036
Optical Data Storage
compact discs inexpensively store software, movies, games and data
037
Hilda Kingslake
an OSA Fellow, she chronicled the history of OSA
042
3D Printing
generates on-demand objects using lasers and "inks" made of plastic, ceramic or metal
043
Katharine Burr Blodgett
invented the "invisible" or non-reflecting glass
044
OSA Presidents
OSA's founding presidents brought vision and leadership to the role that continues to this day
045
Four-Color DNA Sequencing
identifies the order of nucleotides in a DNA fragment
046
Biometrics Systems
use sensors, software, and optics to recognize unique features
047
Ernst Abbe
developed the first optical lenses based on optical theory
048
OSA Local Sections
Local Sections
OSA was founded in Rochester, NY, U.S. in 1916
049
Optics for Kids
OSA provides fun and inspirational interaction with light for kids of all ages
050
Mary Warga
served as OSA's first executive secretary from 1959 to 1972
051
Optical Coherence
052
Chien-Shiung Wu
053
Artificial Retina
054
Anthony
055
Stimulated Emission
056
Adolph Lomb
057
270,000
OSA Community
058
Perley G. Nutting
059
Laser Scanning
060
Frederic Ives and
061
OSA

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Tuesday 1930 – 2100

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Brisbane, Australia, 5 December 2016

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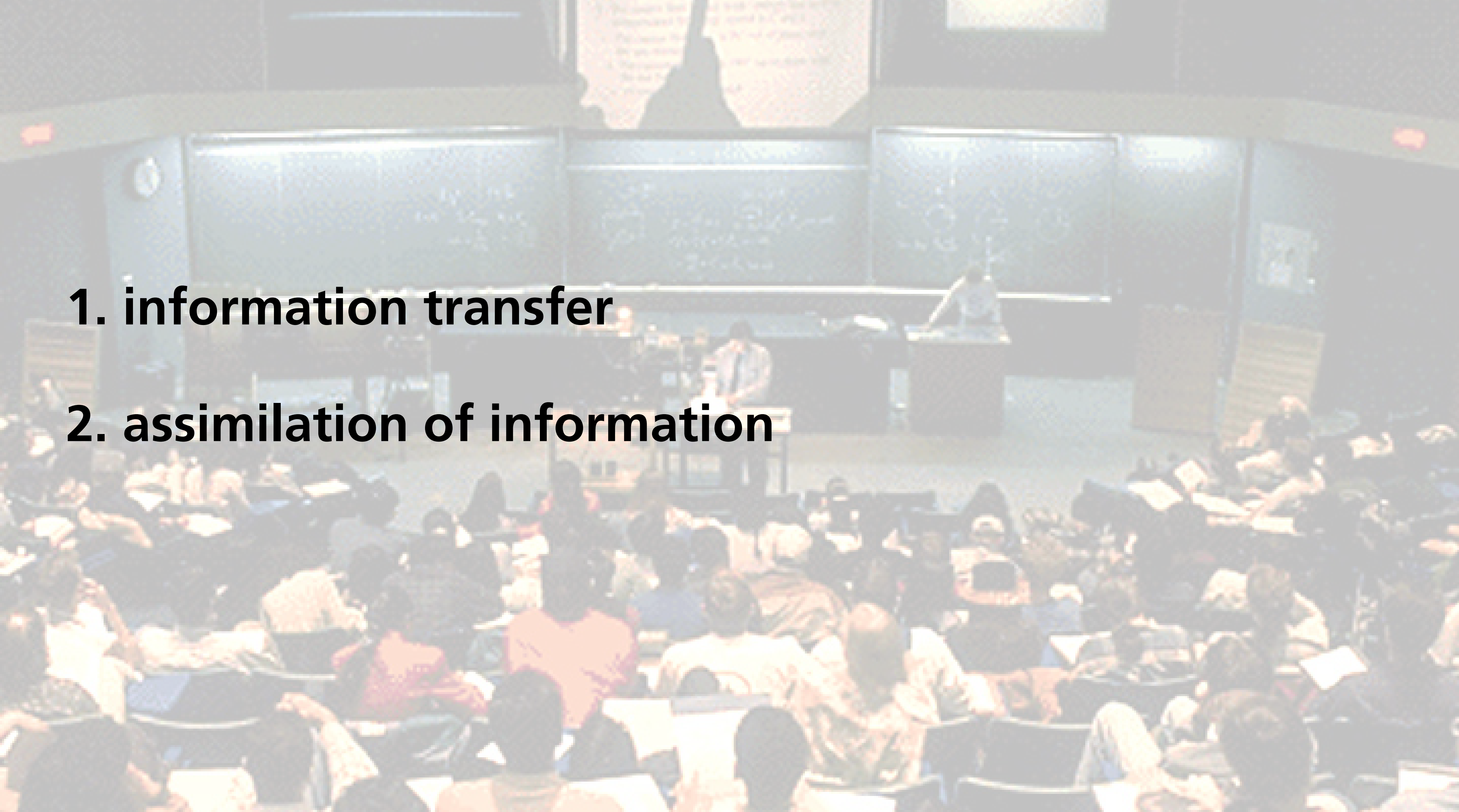
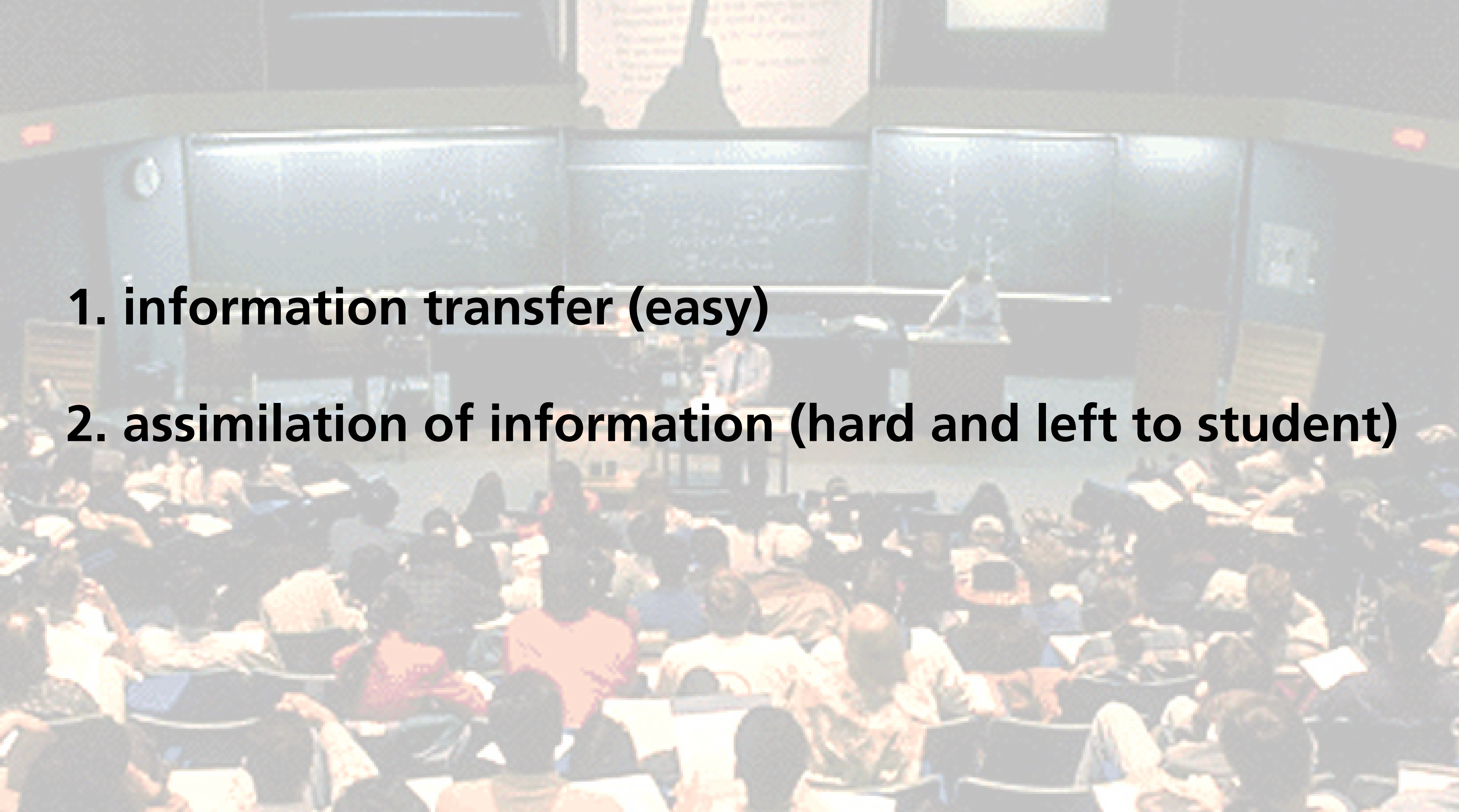
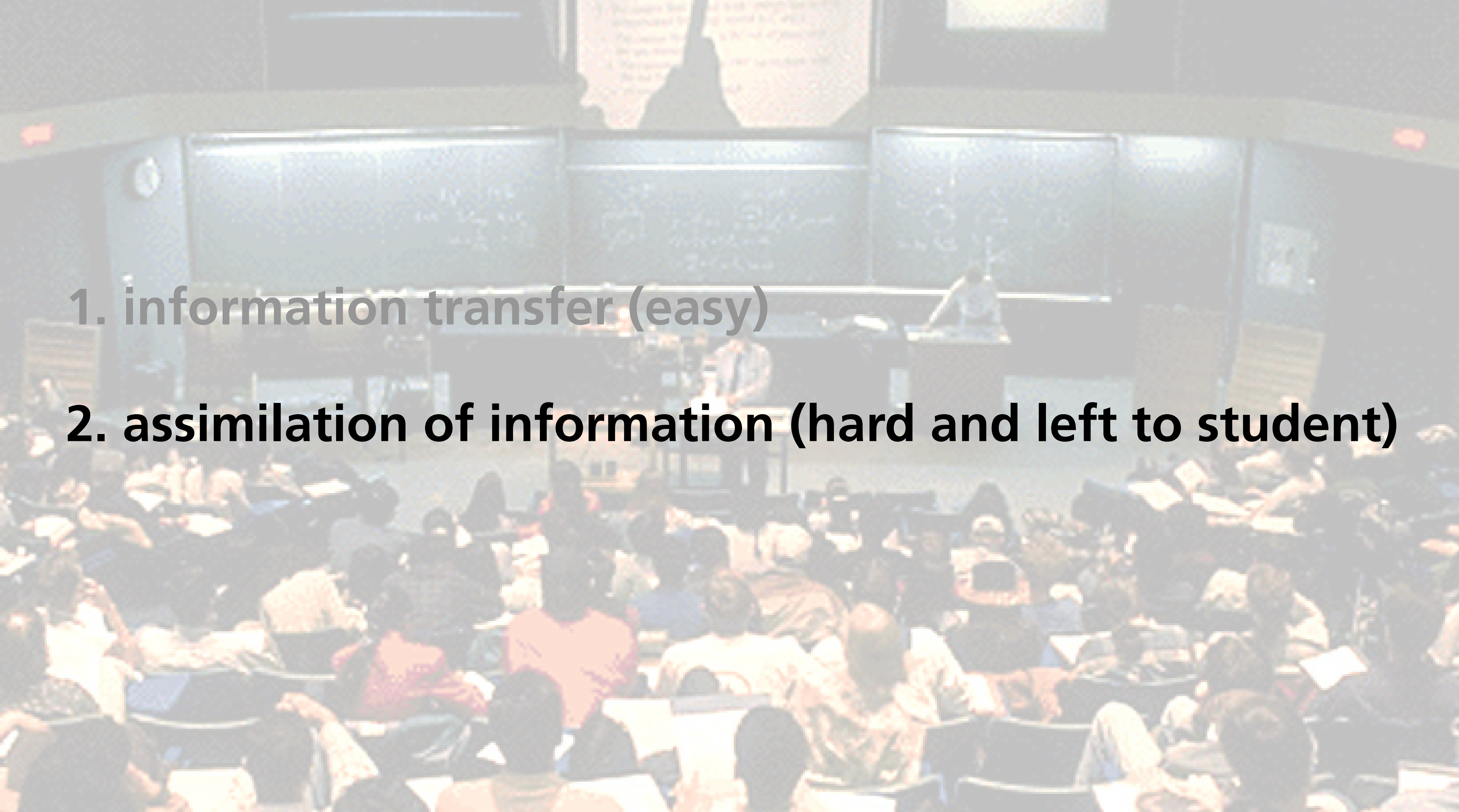


1. information transfer
2. assimilation of information



1. information transfer (easy)

2. assimilation of information (hard and left to student)



1. information transfer (easy)

2. assimilation of information (hard and left to student)

Buoyancy

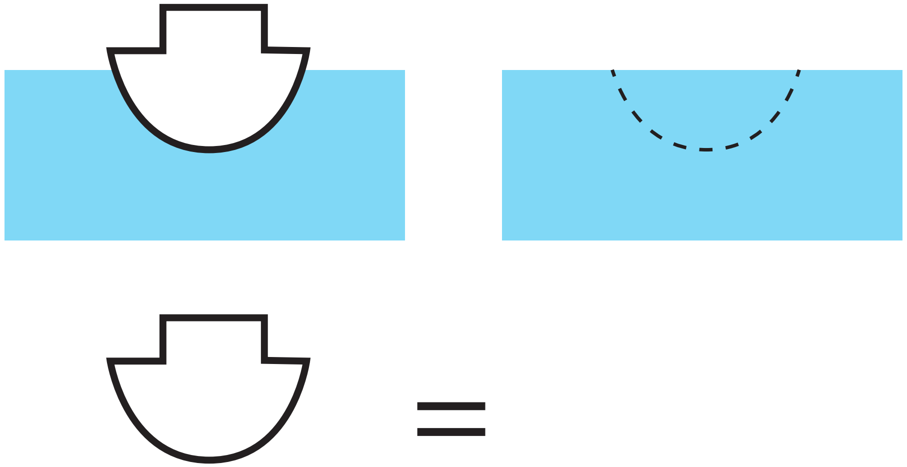
Archimedes’ Principle

Archimedes' Principle

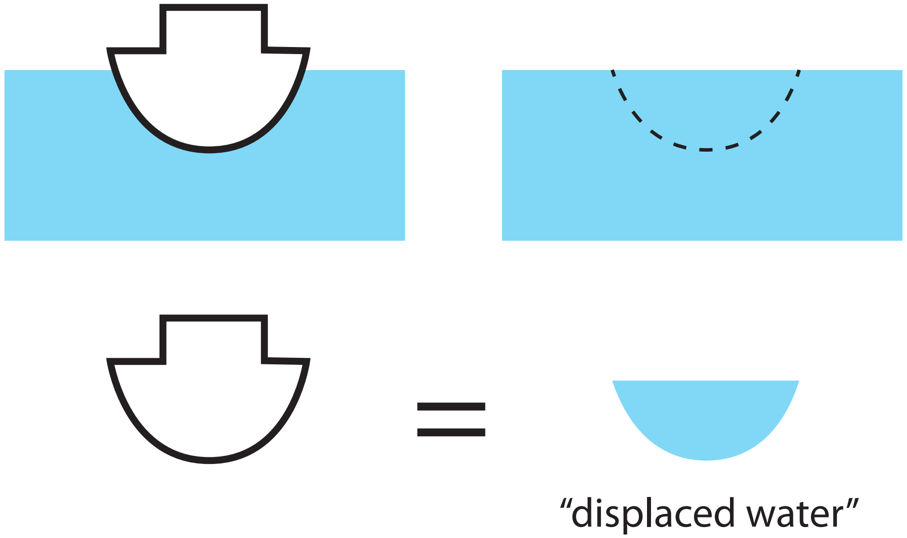
An object submerged either fully or partially in a fluid experiences an upward buoyant force the magnitude of which is equal to the magnitude of the force of gravity exerted on the fluid displaced by the object. The volume of displaced fluid is equal to the volume of the submerged portion of the object.

Archimedes' Principle

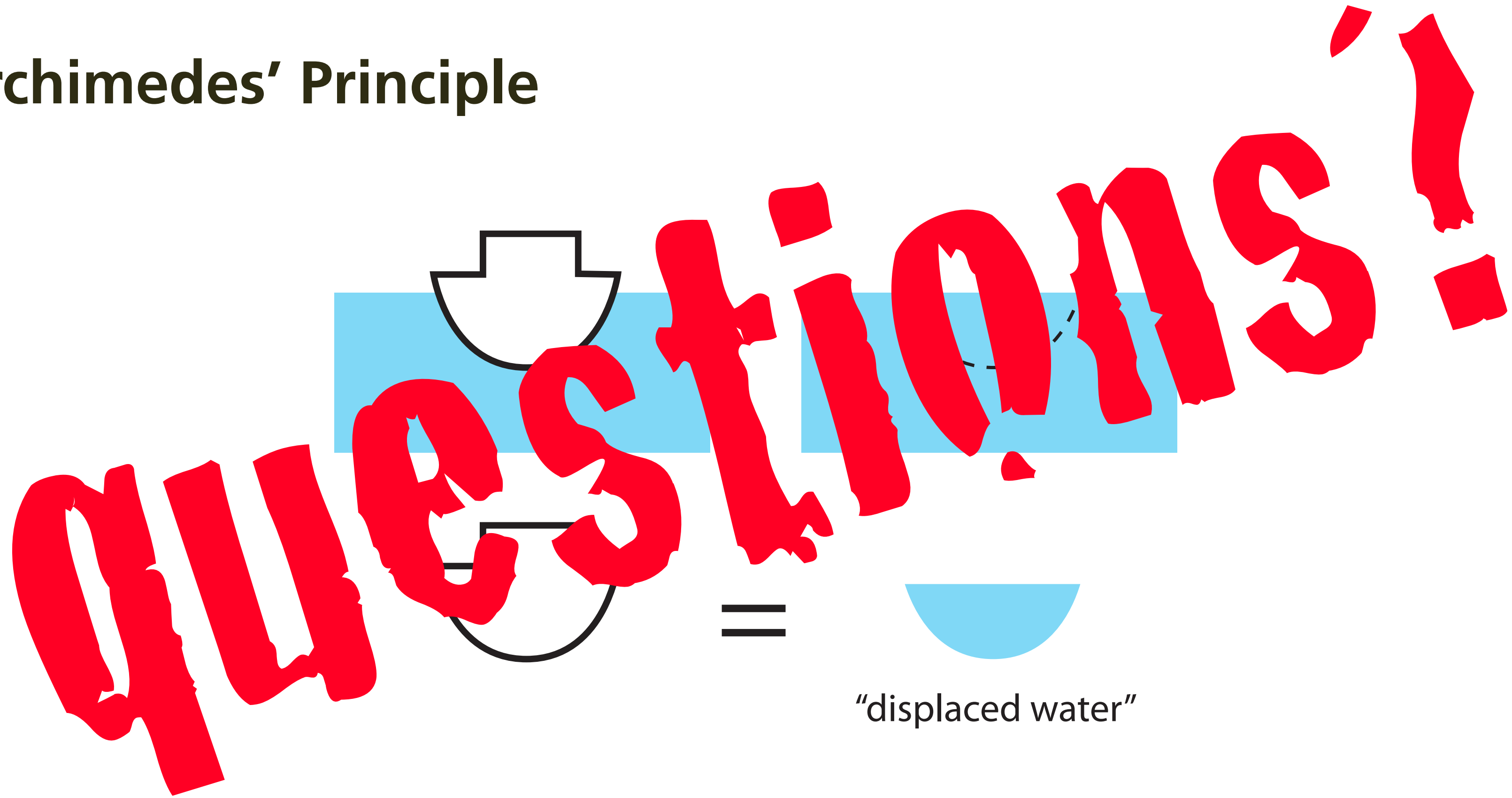
Archimedes' Principle



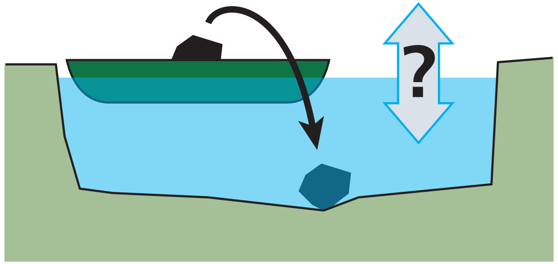
Archimedes’ Principle



Archimedes’ Principle



A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.



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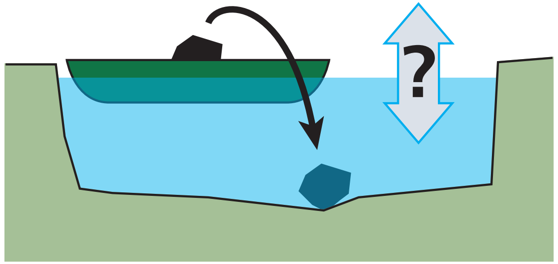

After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than,
2. the same as,
3. lower than it was when the boulder was in the boat.

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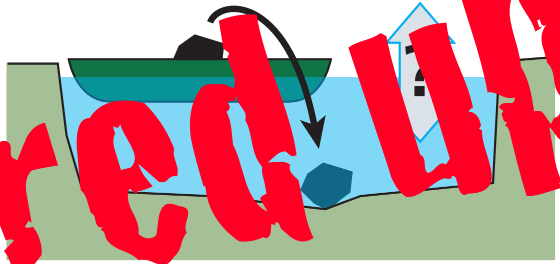


After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than,
2. the same as,
3. lower than it was when the boulder was in the boat.

you got all fired up!

Before I tell you the answer, let’s analyze what happened.

Before I tell you the answer, let's analyze what happened.

You…

Before I tell you the answer, let's analyze what happened.

You…

1. made a commitment

Before I tell you the answer, let's analyze what happened.

You…

1. made a commitment

Before I tell you the answer, let's analyze what happened.

You…

1. **made a commitment**
2. **externalized your answer**

Before I tell you the answer, let’s analyze what happened.

You…

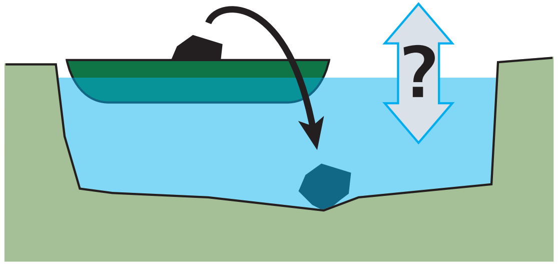
1. **made a commitment**
2. **externalized your answer**
3. **moved from the answer/fact to reasoning**

Before I tell you the answer, let's analyze what happened.

You…

1. **made a commitment**
2. **externalized your answer**
3. **moved from the answer/fact to reasoning**
4. **became emotionally invested in the learning process**

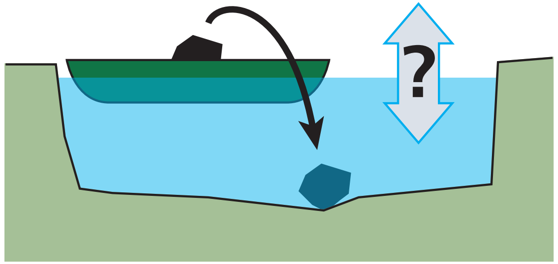
A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.



After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than,
2. the same as,
3. lower than it was when the boulder was in the boat.

A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.

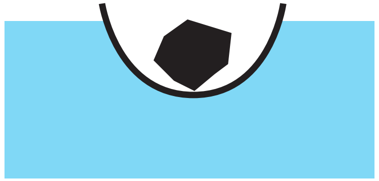


After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than
2. the same as
3. lower than it was when the boulder was in the boat. ✔

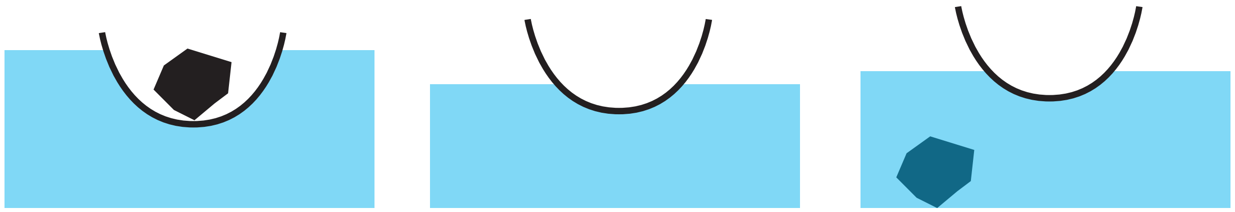
remember: amount of displaced water

remember: amount of displaced water

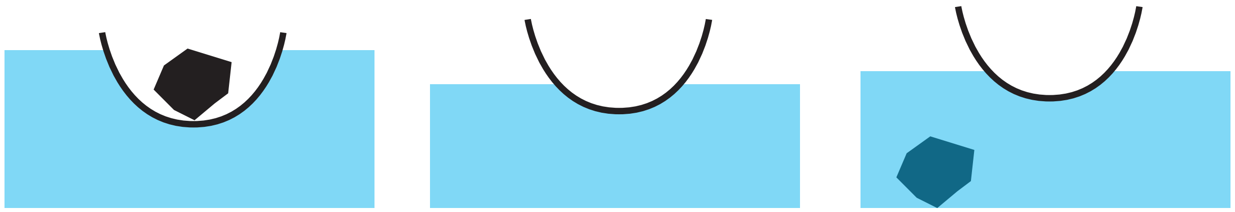


remember: amount of displaced water

remember: amount of displaced water

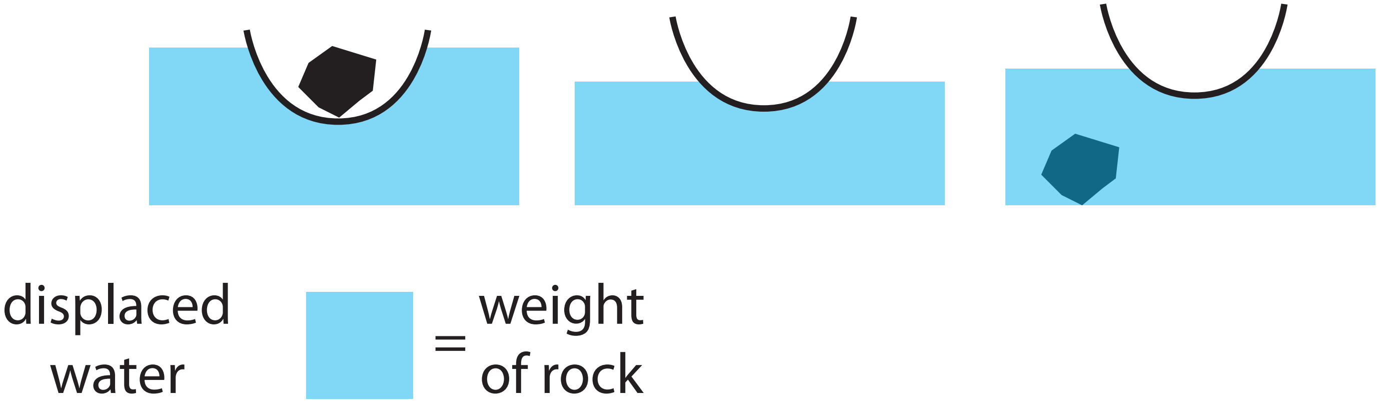


remember: amount of displaced water

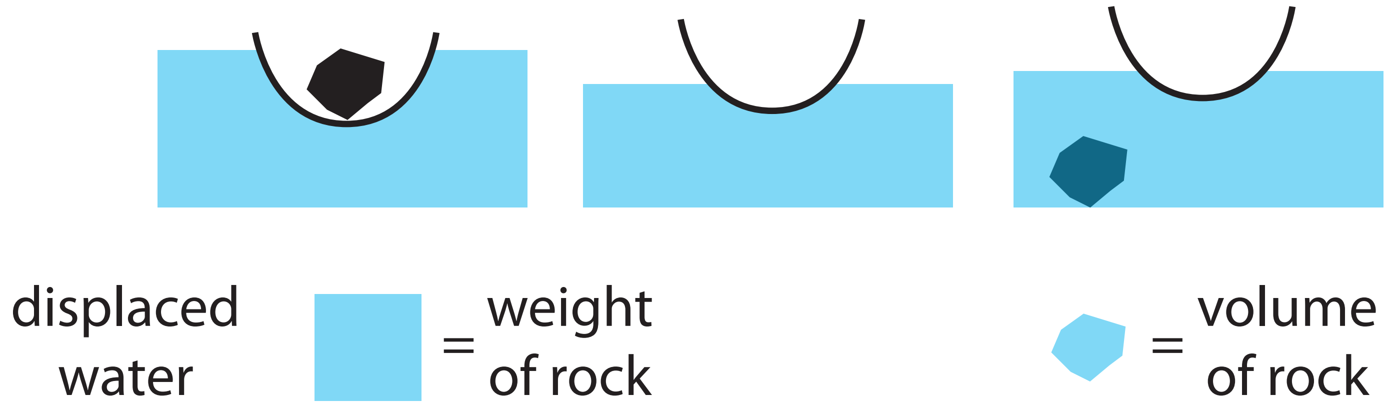


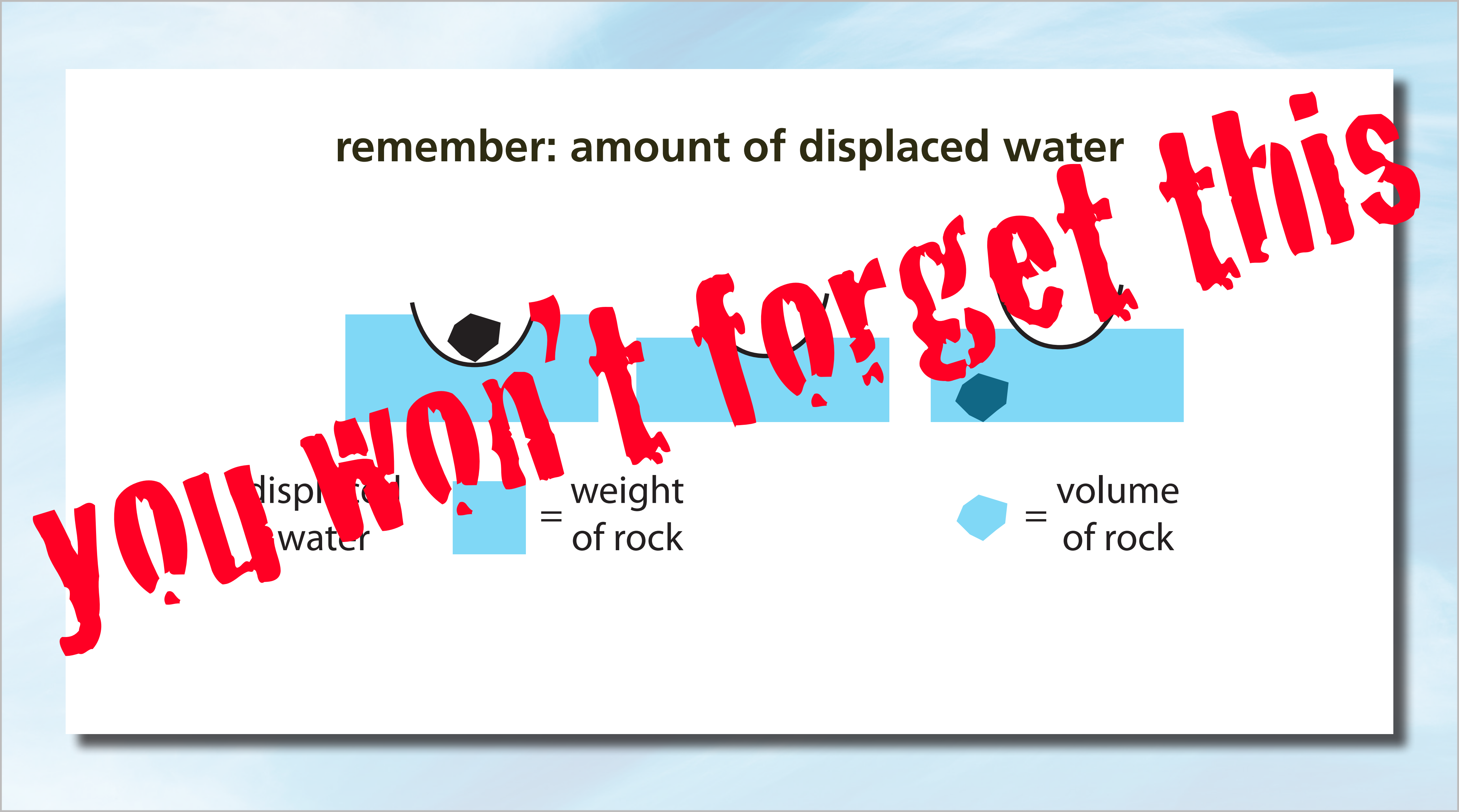
displaced
water

remember: amount of displaced water



remember: amount of displaced water

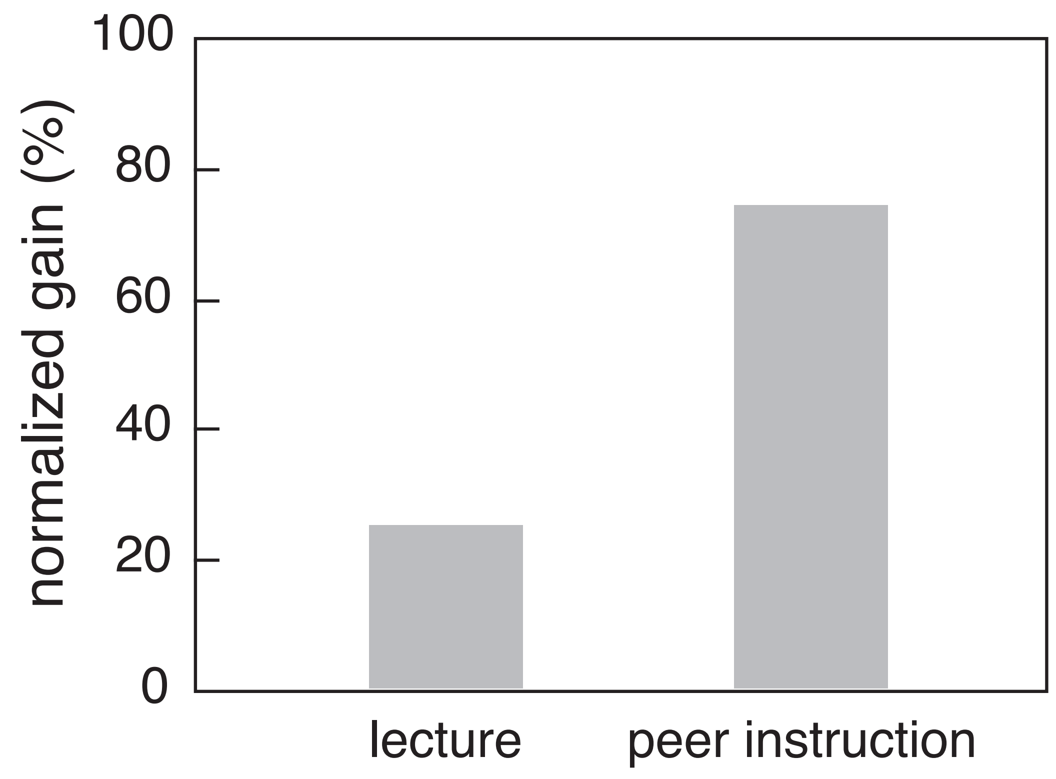



remember: amount of displaced water
you won't forget this
weight
of rock
volume
of rock


back to Pl
INSTRUCTION

Higher learning gains

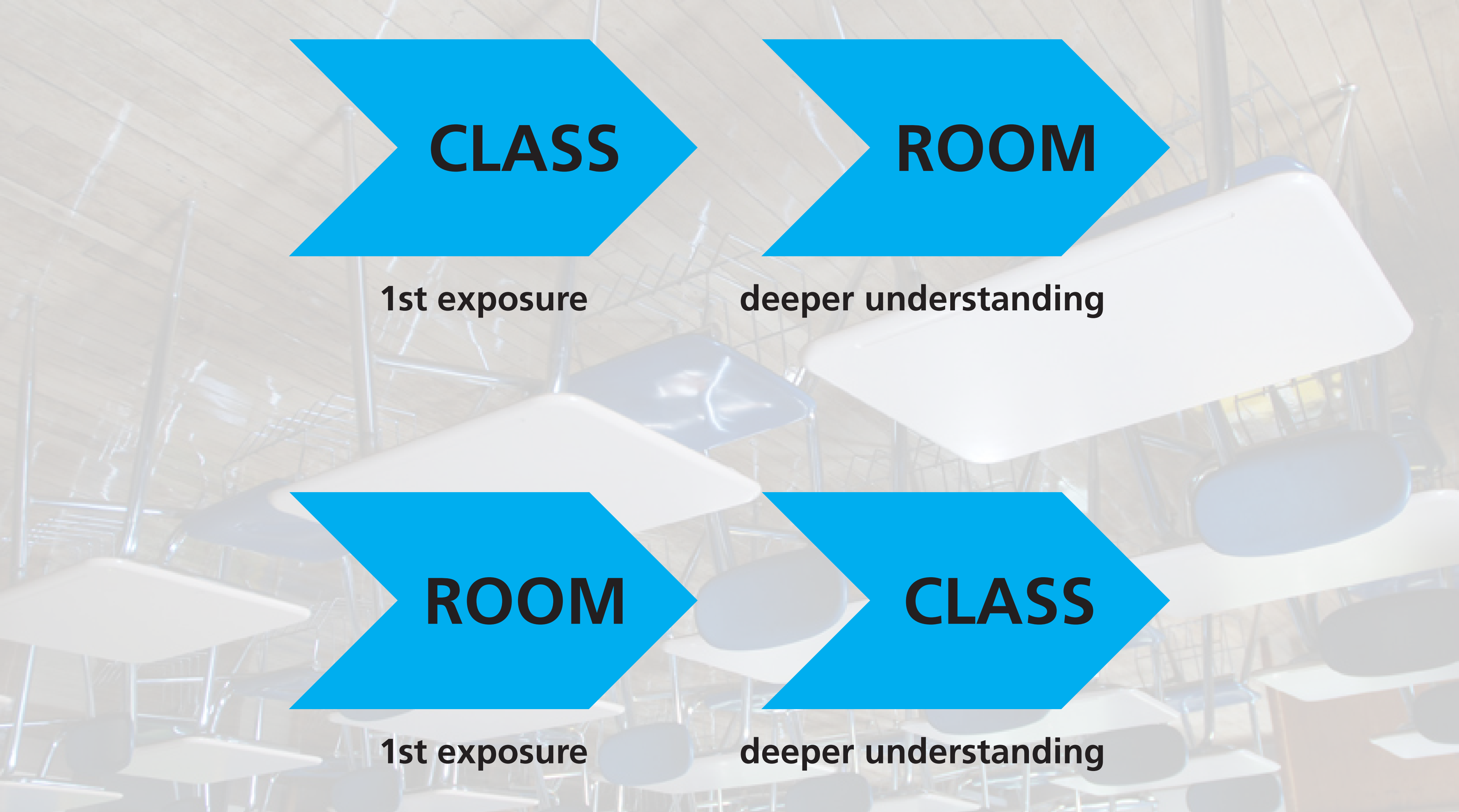
INSTRUCTION

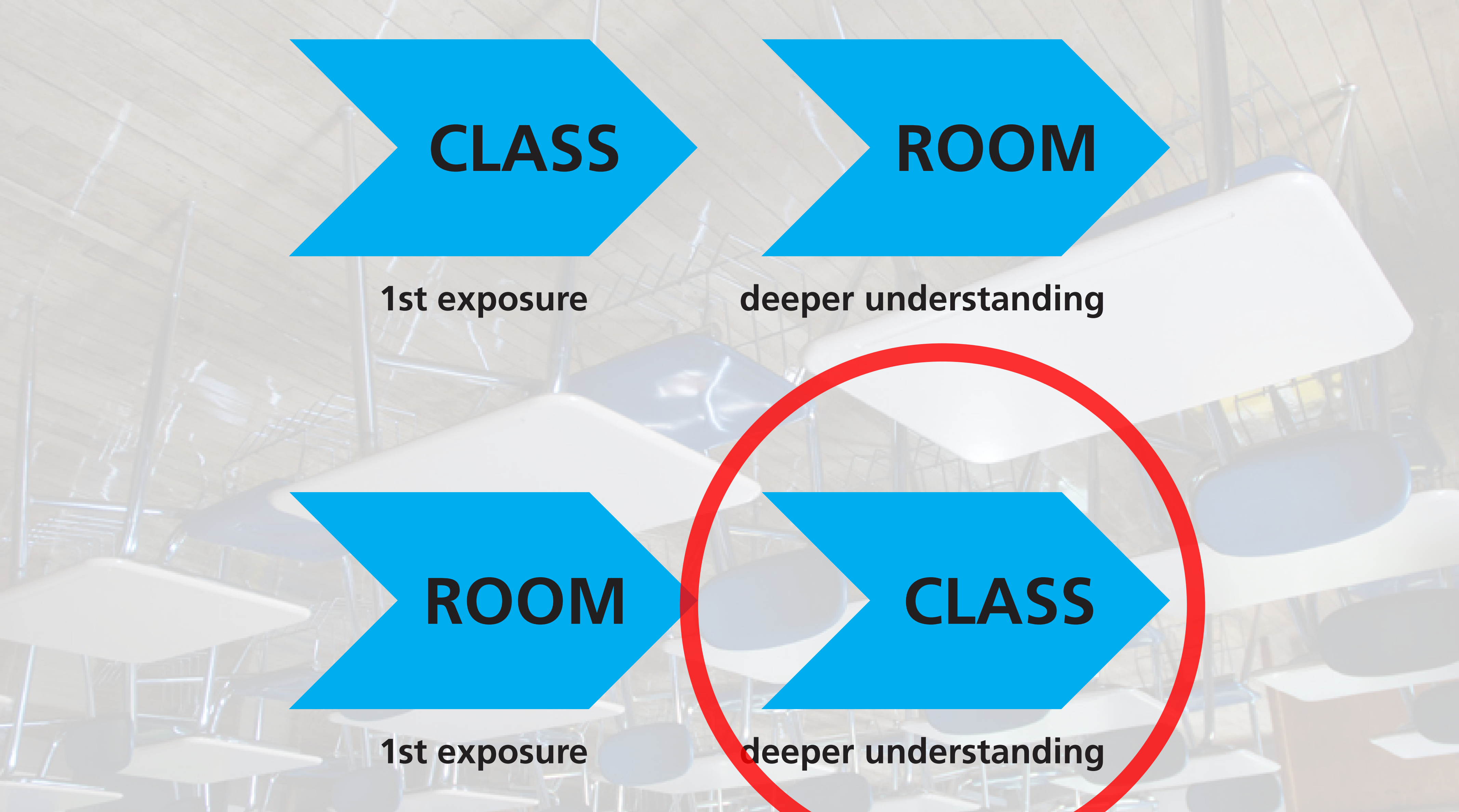

normalized gain (%)
0
20
40
60
80
100
lecture
peer instruction

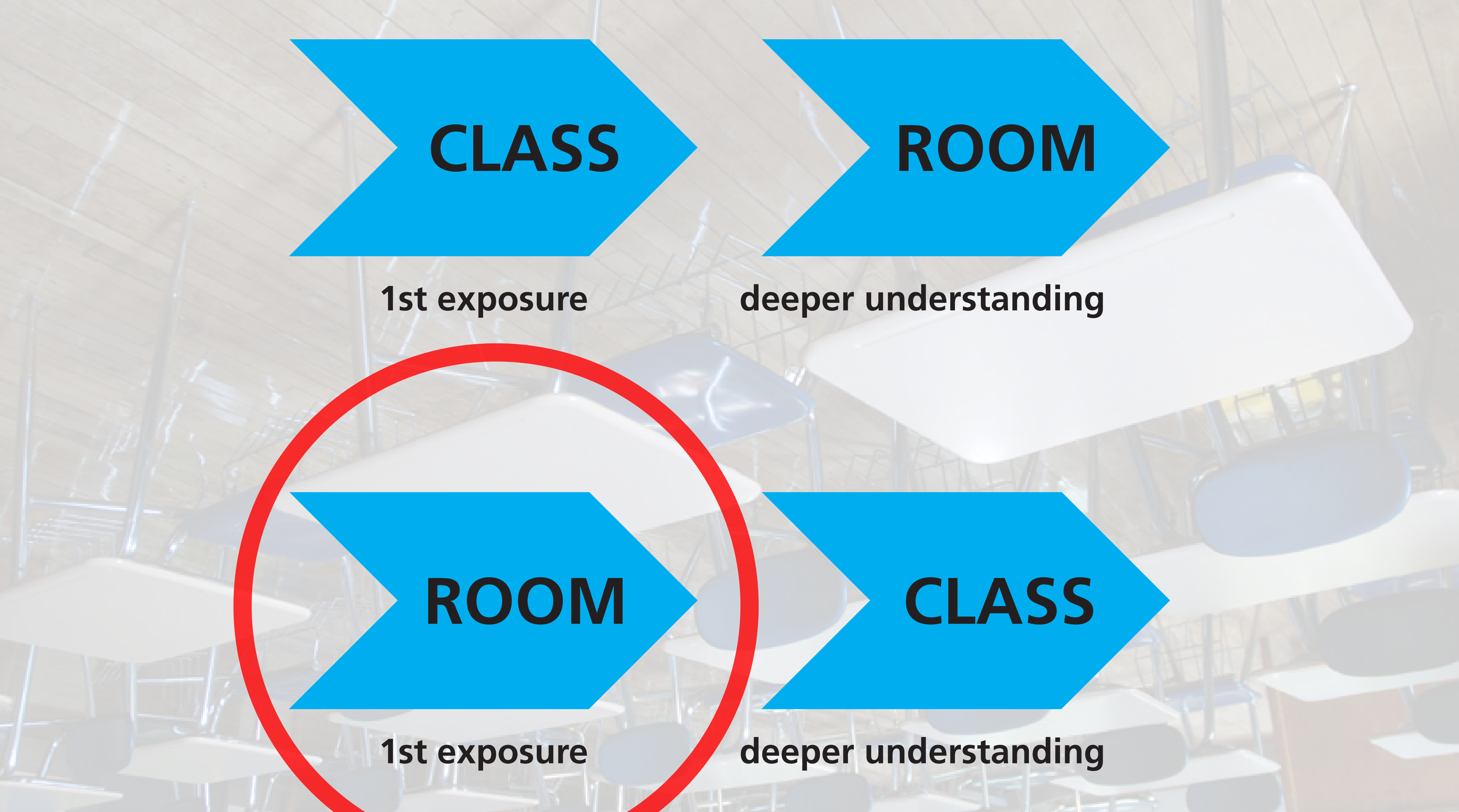
Higher learning gains

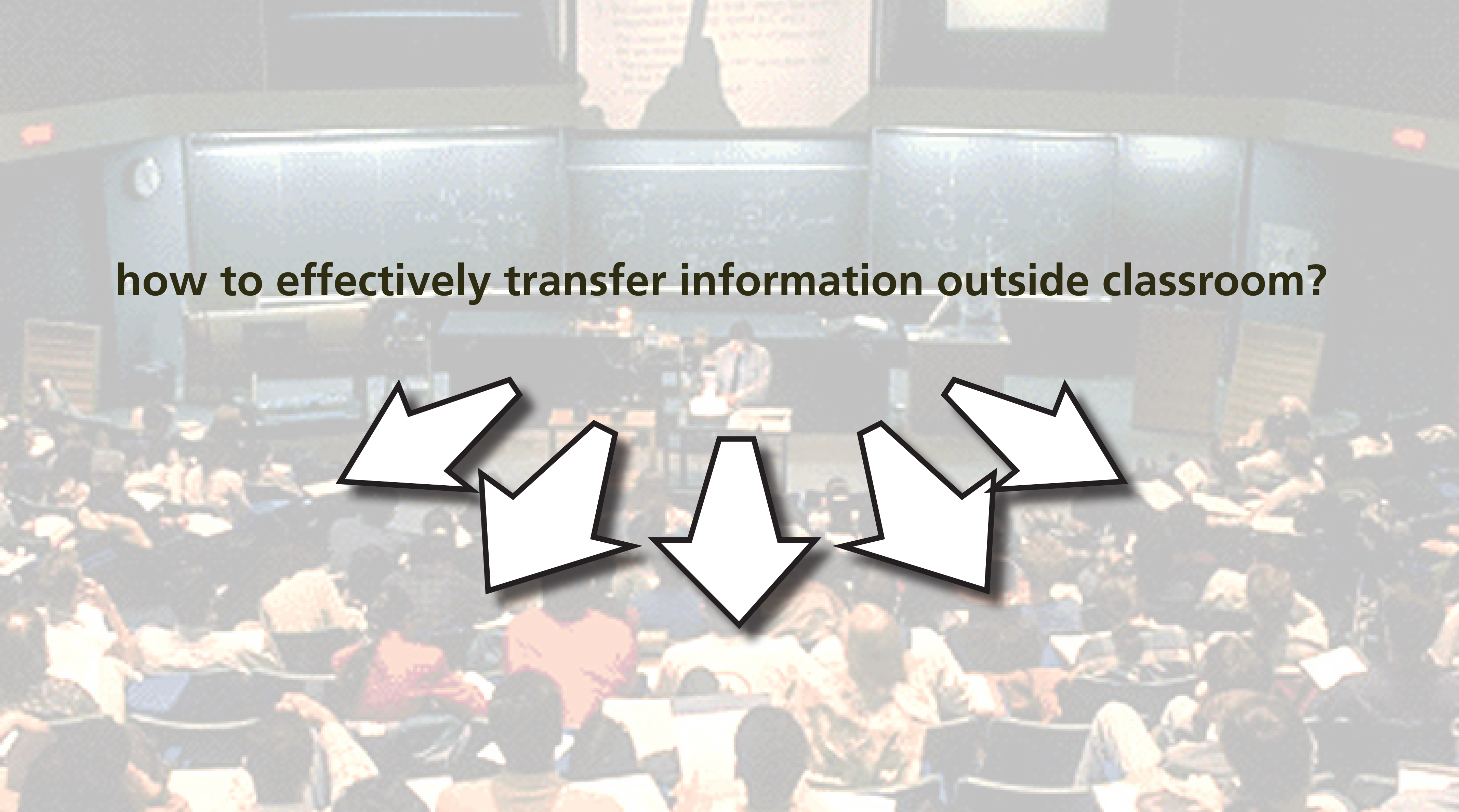
Better retention


CLASS
ROOM
1st exposure
deeper understanding


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


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

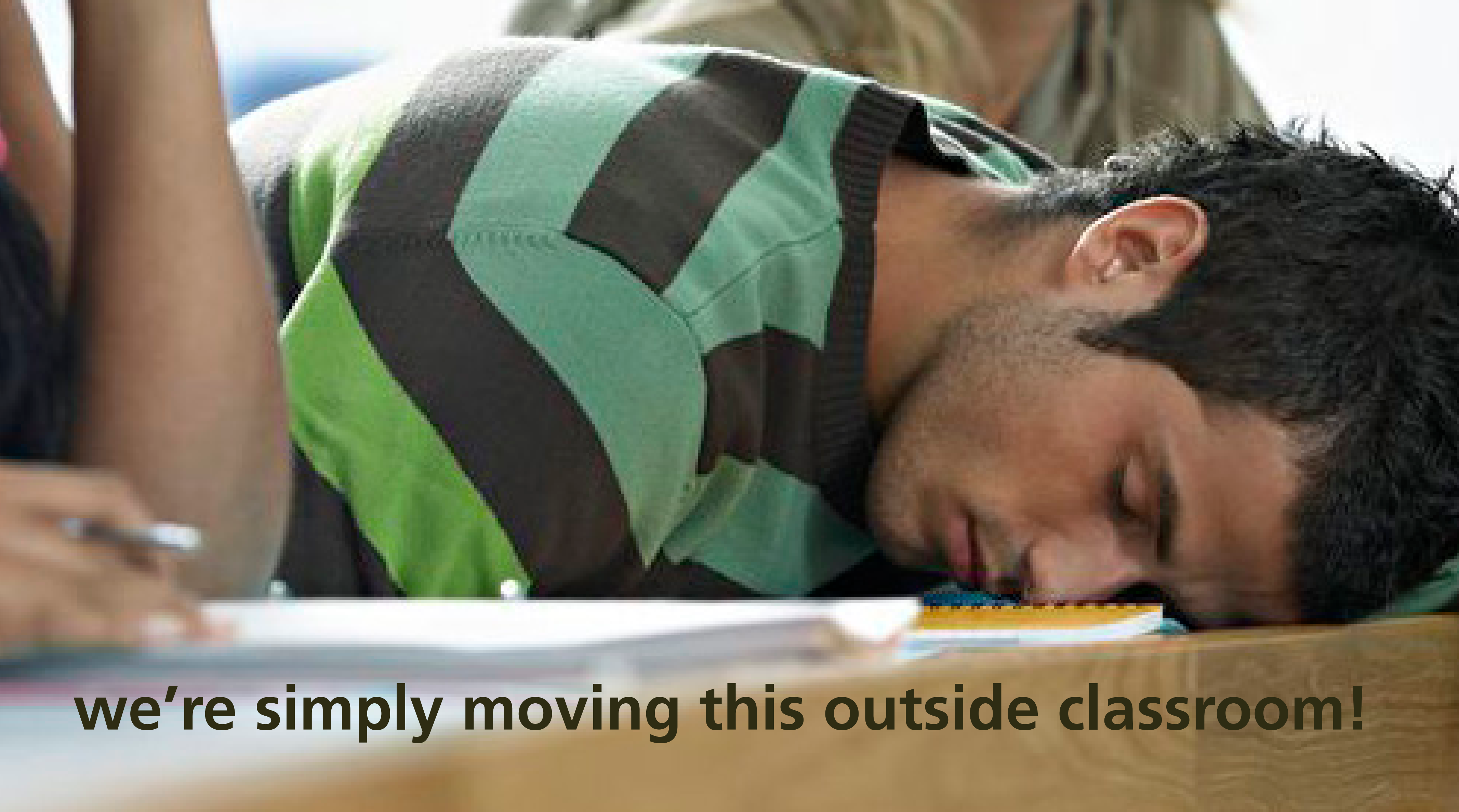

CLASS
ROOM
1st exposure
deeper understanding
ROOM
CLASS
1st exposure
deeper understanding

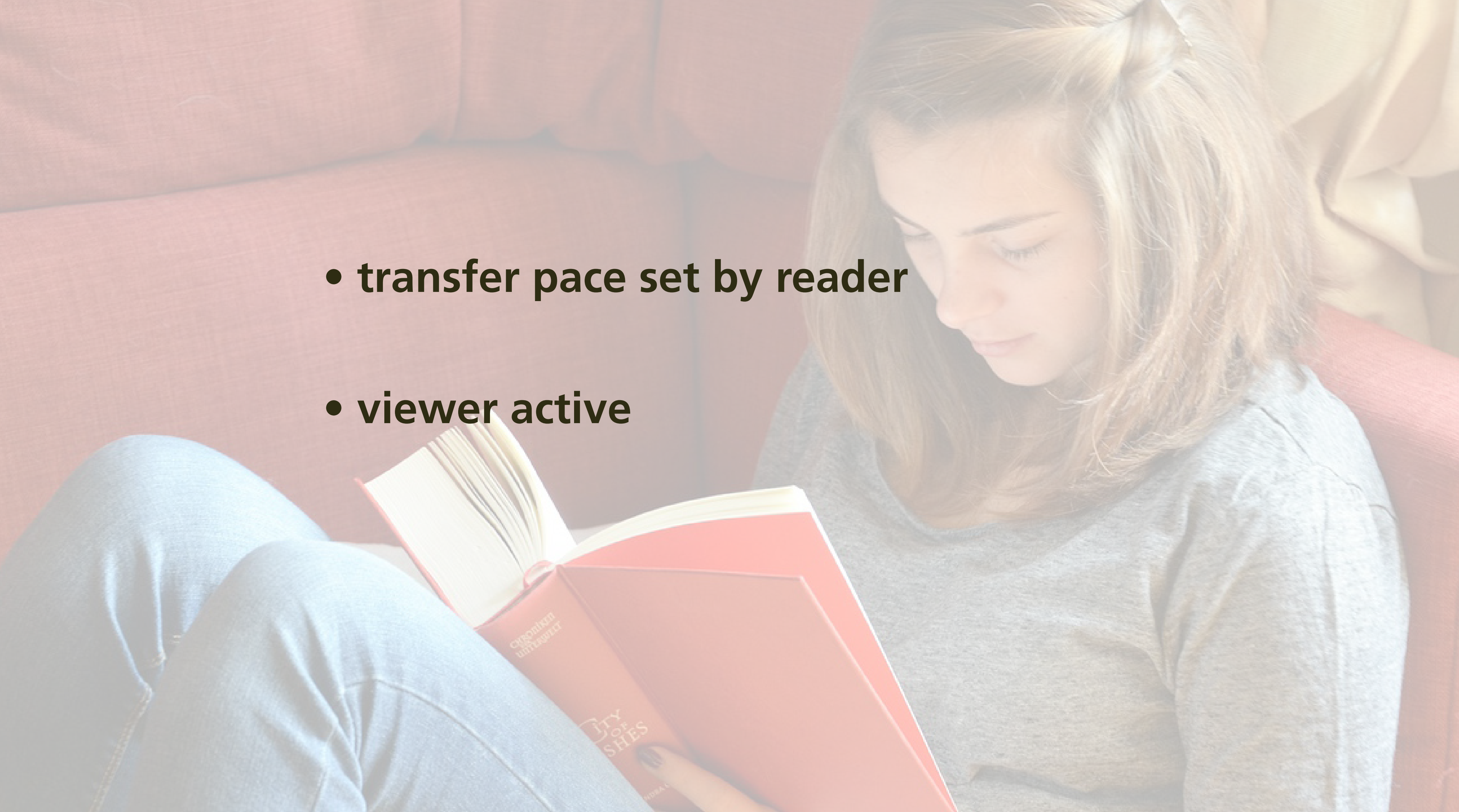

how to effectively transfer information outside classroom?


P=4a
a
d


but…

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


we’re simply moving this outside classroom!



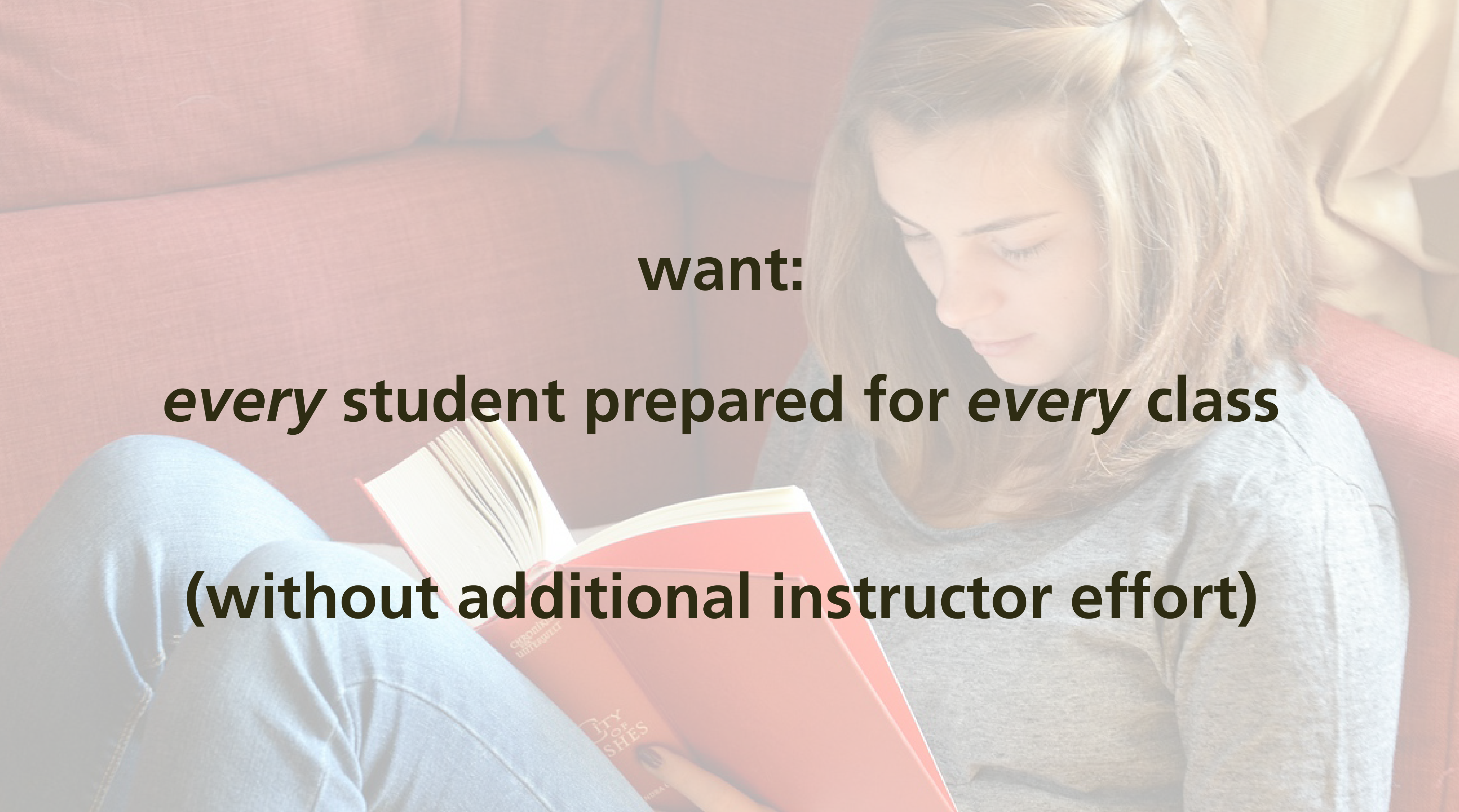
- **transfer pace set by reader**
- **viewer active**

but…


isolated/individual experience &
no real accountability

want:

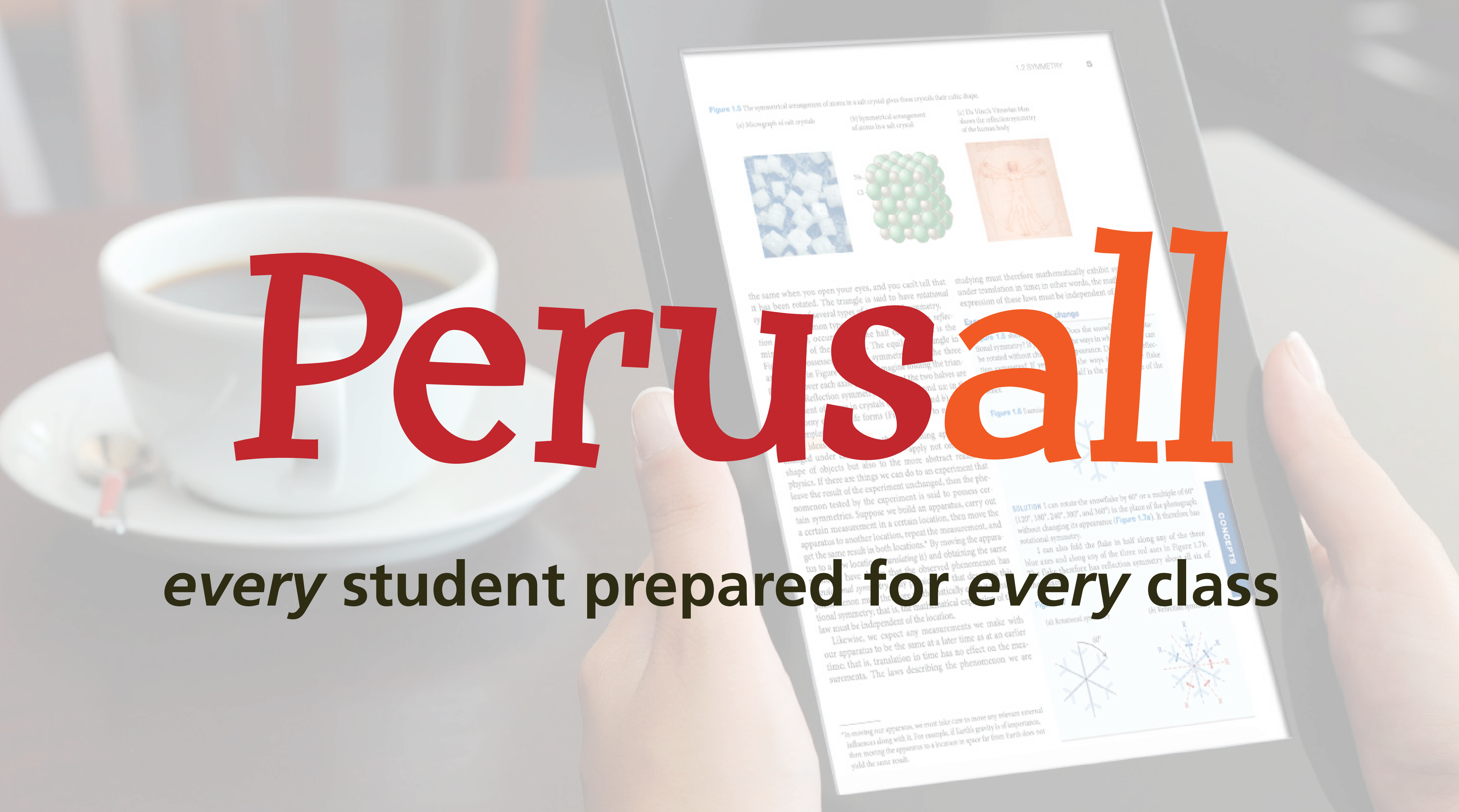
***every* student prepared for *every* class**


want:
every student prepared for *every* class
(without additional instructor effort)

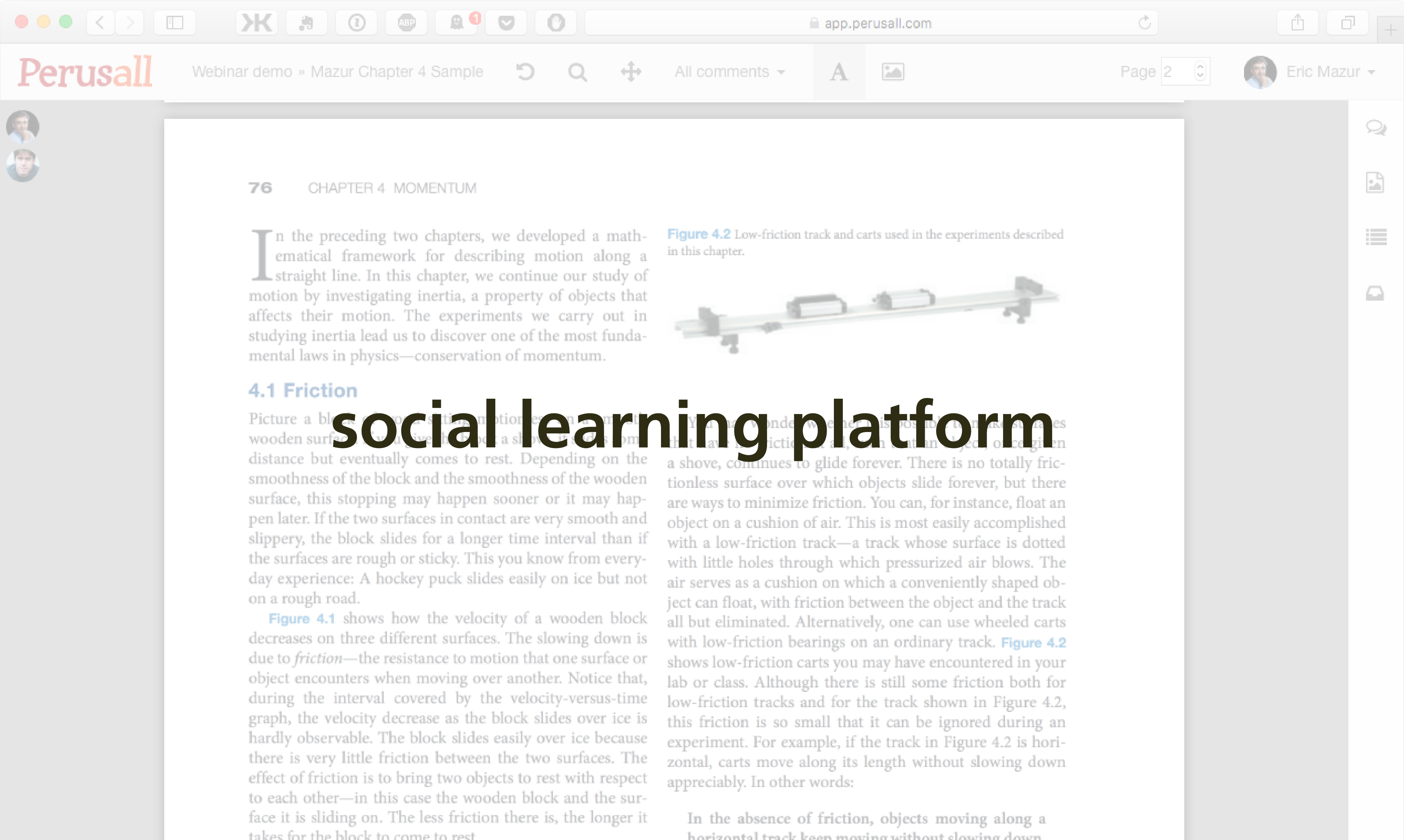
Solution

turn out-of-class component

also into a social interaction!


Perusall
every student prepared for every class

social learning platform



log in through social network

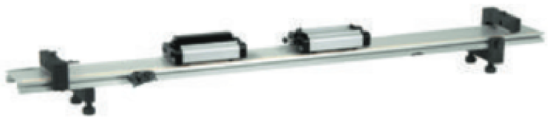
In the preceding two chapters, we developed a mathematical framework for describing motion along a straight line. In this chapter, we continue our study of motion by investigating inertia, a property of objects that affects their motion. The experiments we carry out in studying inertia lead us to discover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

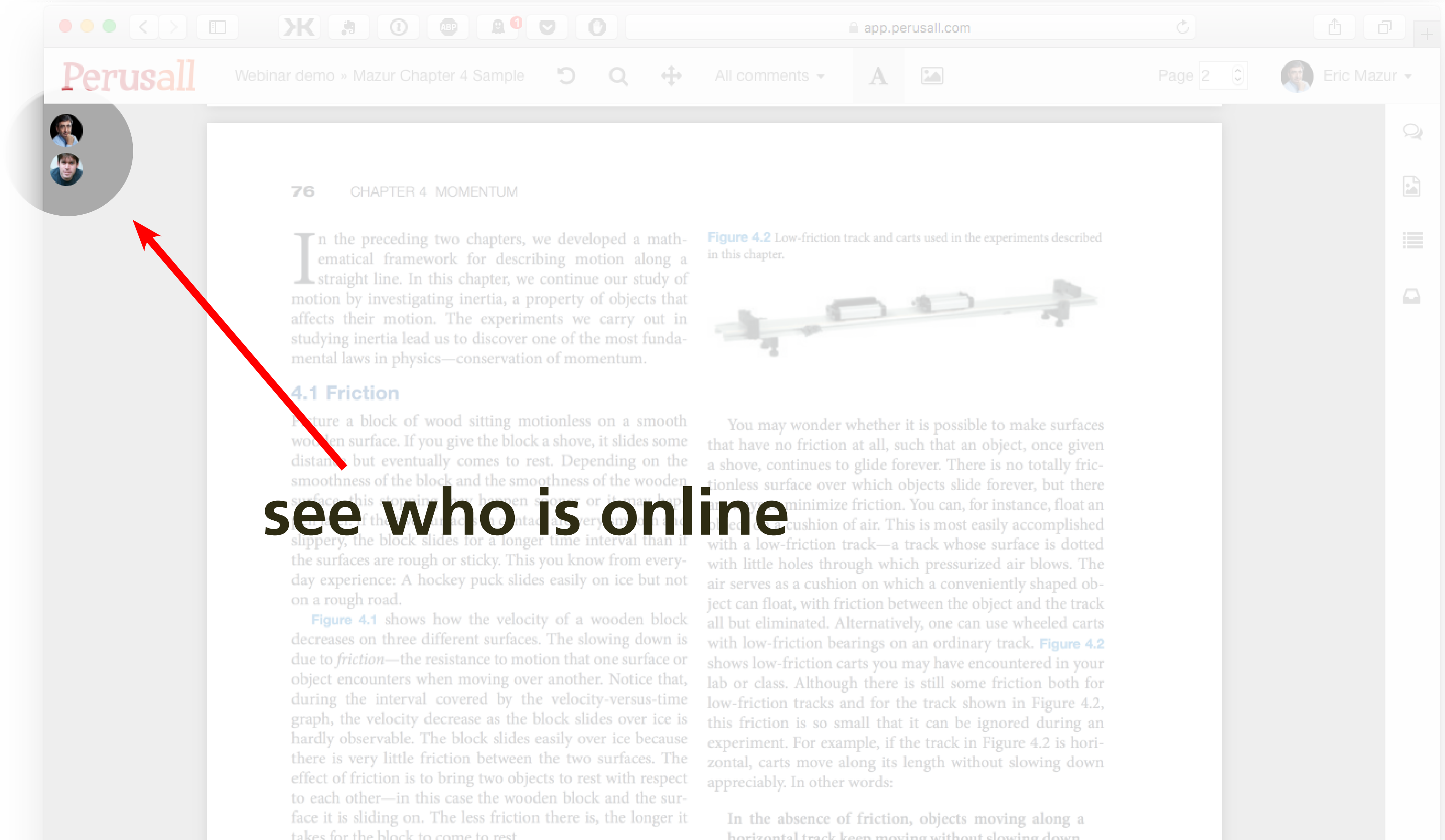
Figure 4.1 shows how the velocity of a wooden block decreases on three different surfaces. The slowing down is due to *friction*—the resistance to motion that one surface or object encounters when moving over another. Notice that, during the interval covered by the velocity-versus-time graph, the velocity 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 4.2 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.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Webinar demo » Mazur Chapter 4 Sample
All comments
Page 2
Eric Mazur
76 CHAPTER 4 MOMENTUM
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
Figure 4.2 Low-friction track and carts used in the experiments described in this chapter.
see who is online

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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.

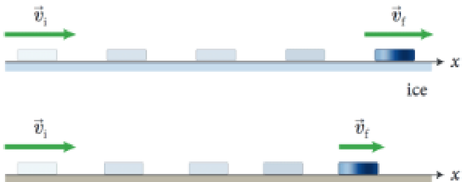
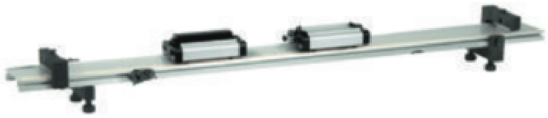


Figure 4.2 Low-friction track and carts used in the experiments described in this chapter.



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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?

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.

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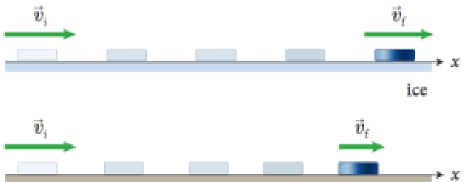
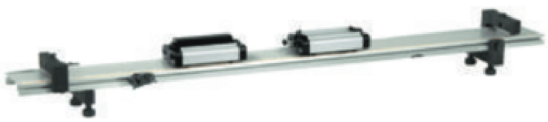


Figure 4.2 Low-friction track and carts used in the experiments described in this chapter.



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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?

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.

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Enter your comment or question and press Enter

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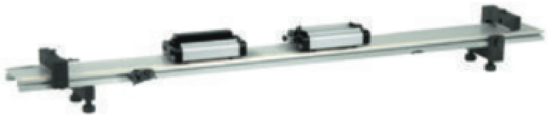

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No friction at all seems impossible. Isn't there always some friction in any real case.

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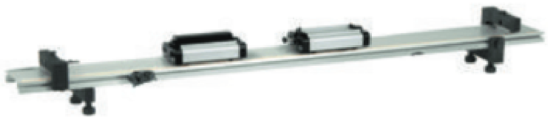

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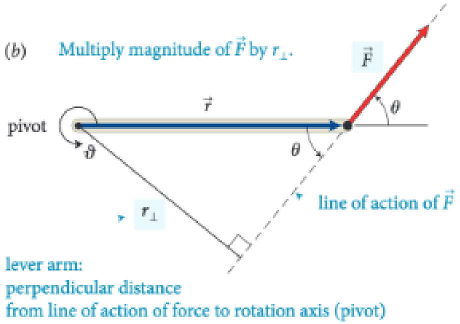
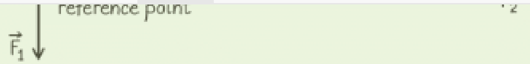


action of the force and the axis of rotation. So, the torque caused by a force exerted on an object is the product of the magnitude of the force and its lever arm distance. It can be written equivalently as $rF_\perp$ and as $r_\perp F$.

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

CONCEPTS



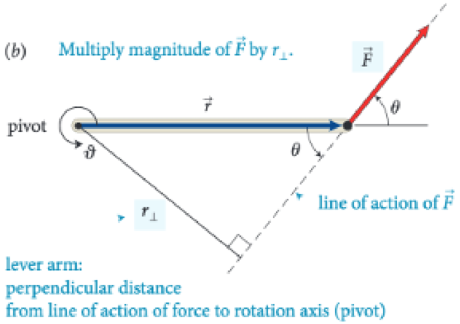
The lever arm distances must now be determined relative to the left end of the rod. The lever arm distance of force $\vec{F}_1$ to this point is zero, and so the torque caused by that force about the left end of the rod is zero. If I choose counterclockwise as the positive direction of rotation, $\vec{F}_2$ 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 12.2c, you must



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

I don't understand how this combination of factors tells you anything about direction? Aren't magnitude and lever arm distance both scalar quantities? It seems like we would need to know some sort of direction to calculate torque. Oct 20 12:09 am

SB I think you may be able to think about the direction separately. So, after multiplying this magnitude and distance, you can attach a sign to the torque based on the defined parameters of the system. In the following paragraph, they start to explain how to choose this direction. Oct 20 12:38 am

This is a great question. To further elaborate on this, we can think of this in terms of the Torque equation. The equation for torque is τ = r X F, with r being the level arm distance and F being force. We know that force is a vector vector from previous Oct 22 8:48 pm

reference point

$\vec{F}_1$

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12.2 In the situation depicted in Figure 12.3a, you must

Perusall

Eric Mazur

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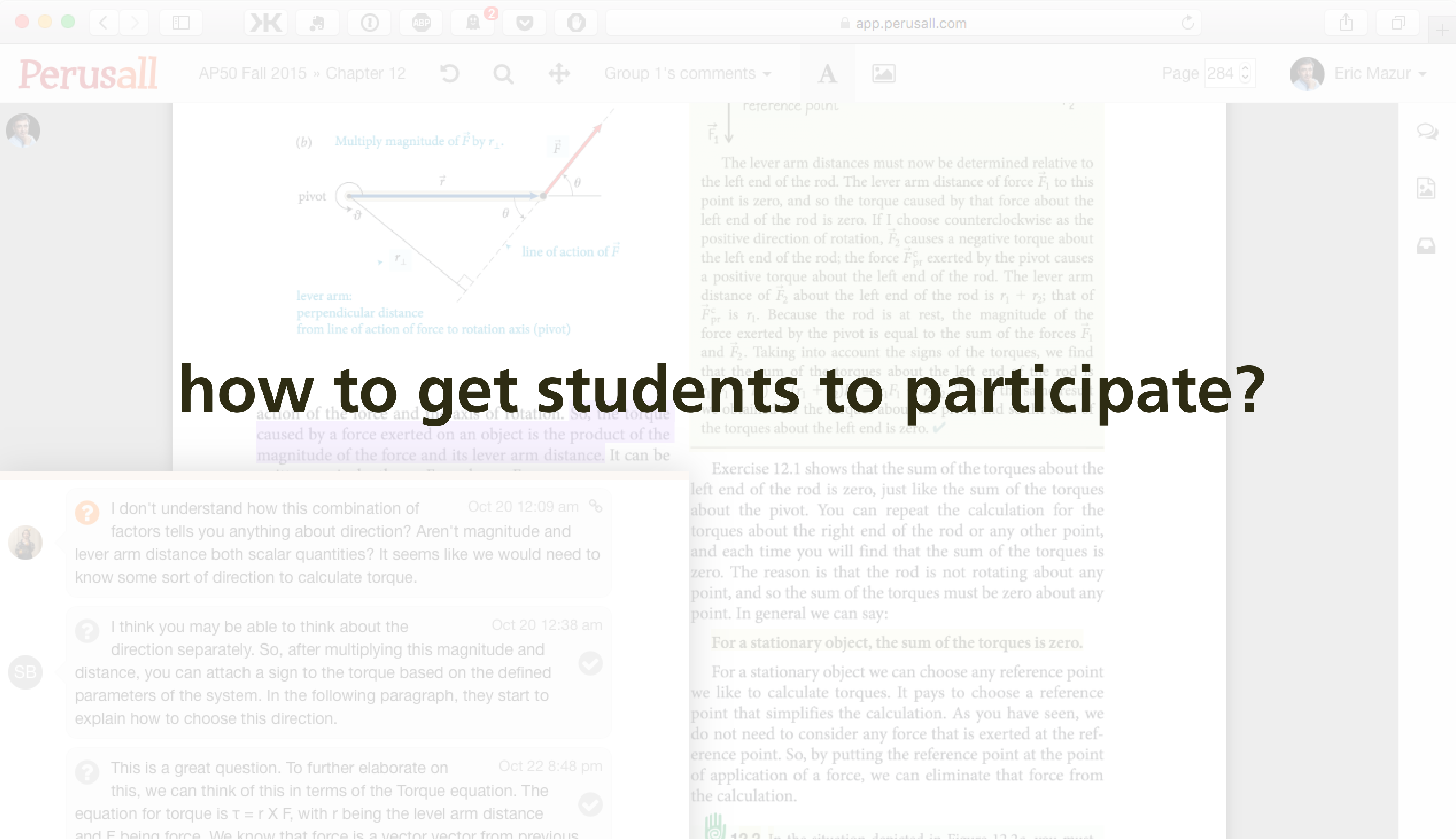
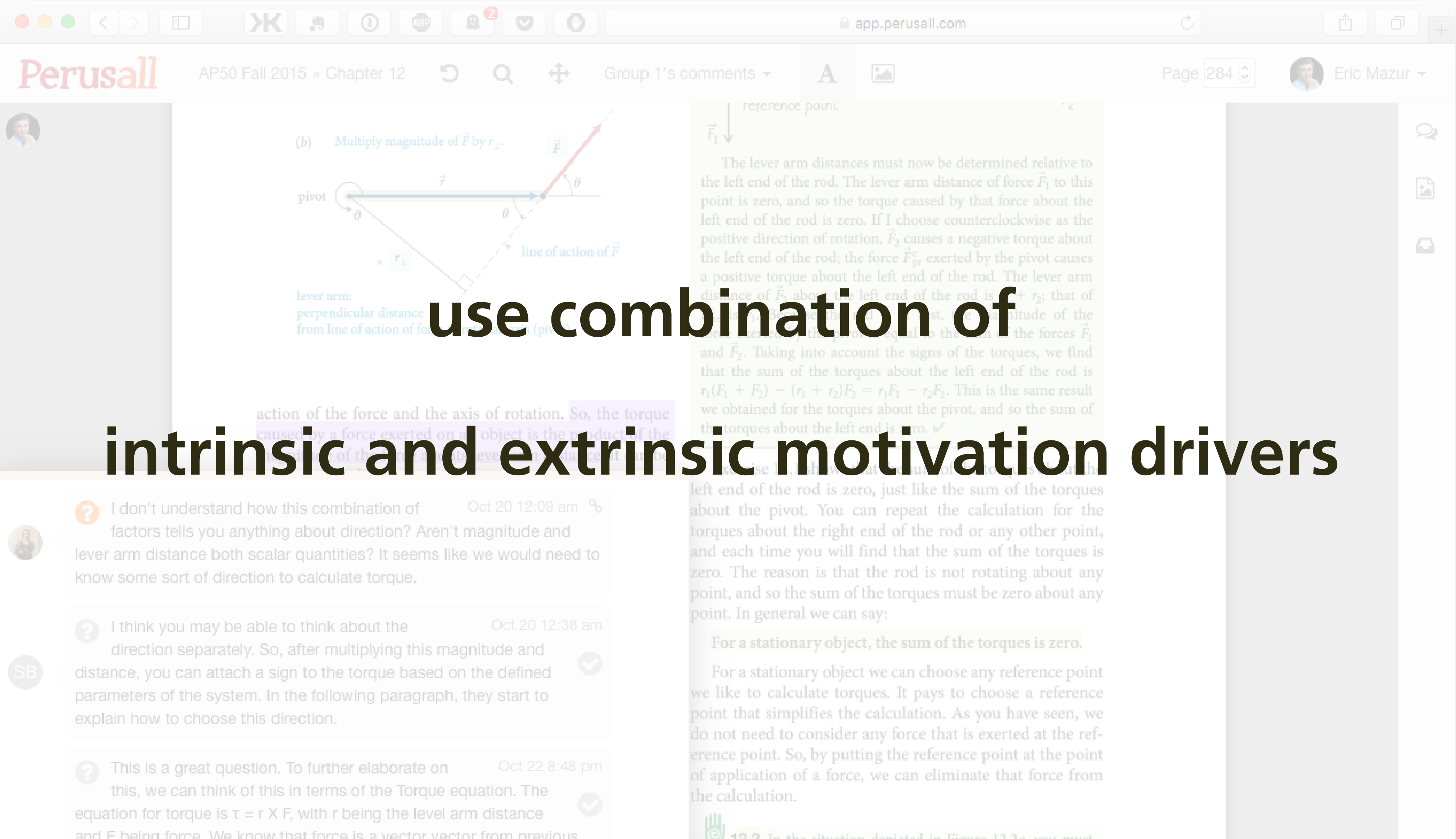
how to get students to participate?

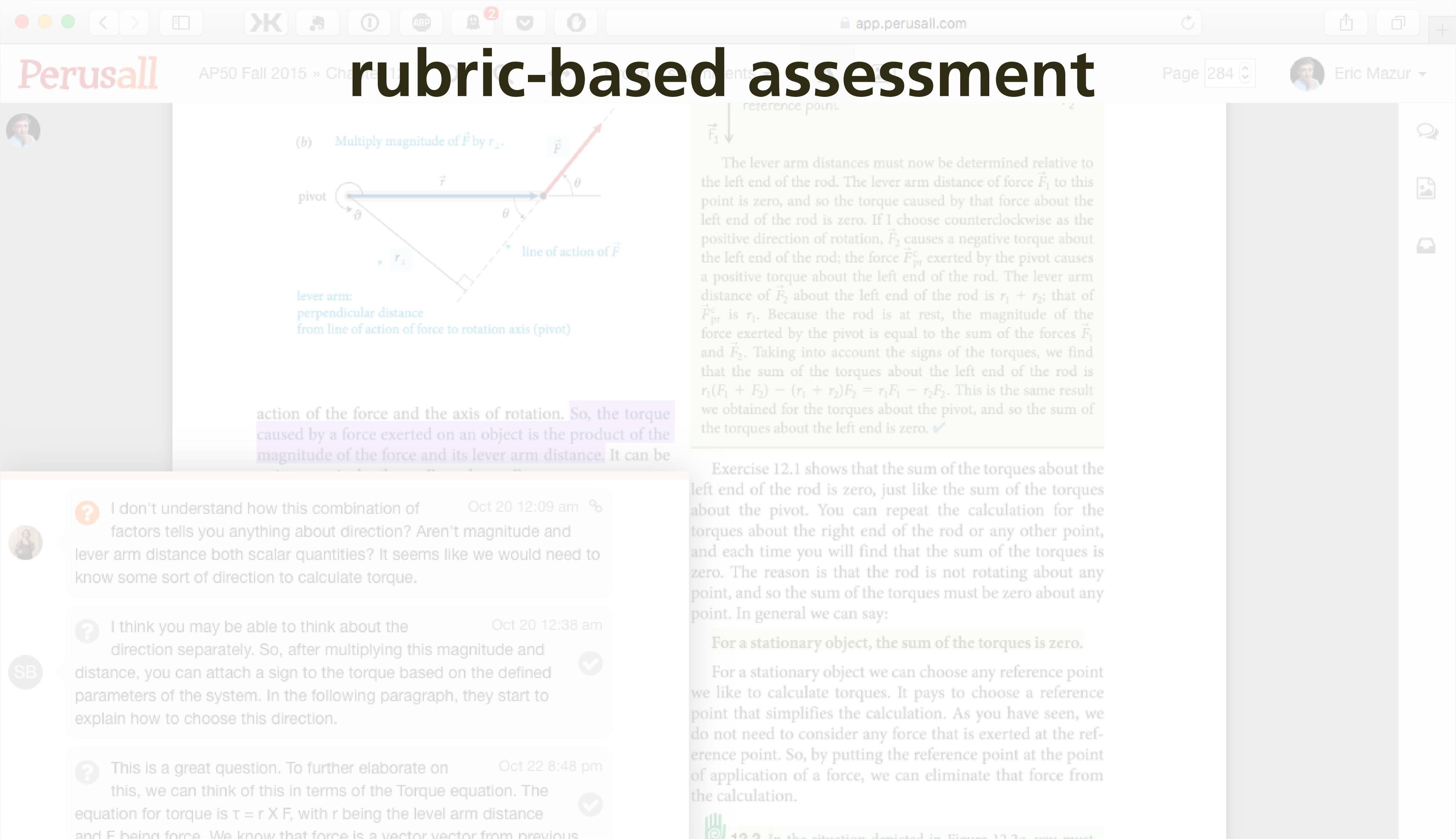


use combination of

intrinsic and extrinsic motivation drivers

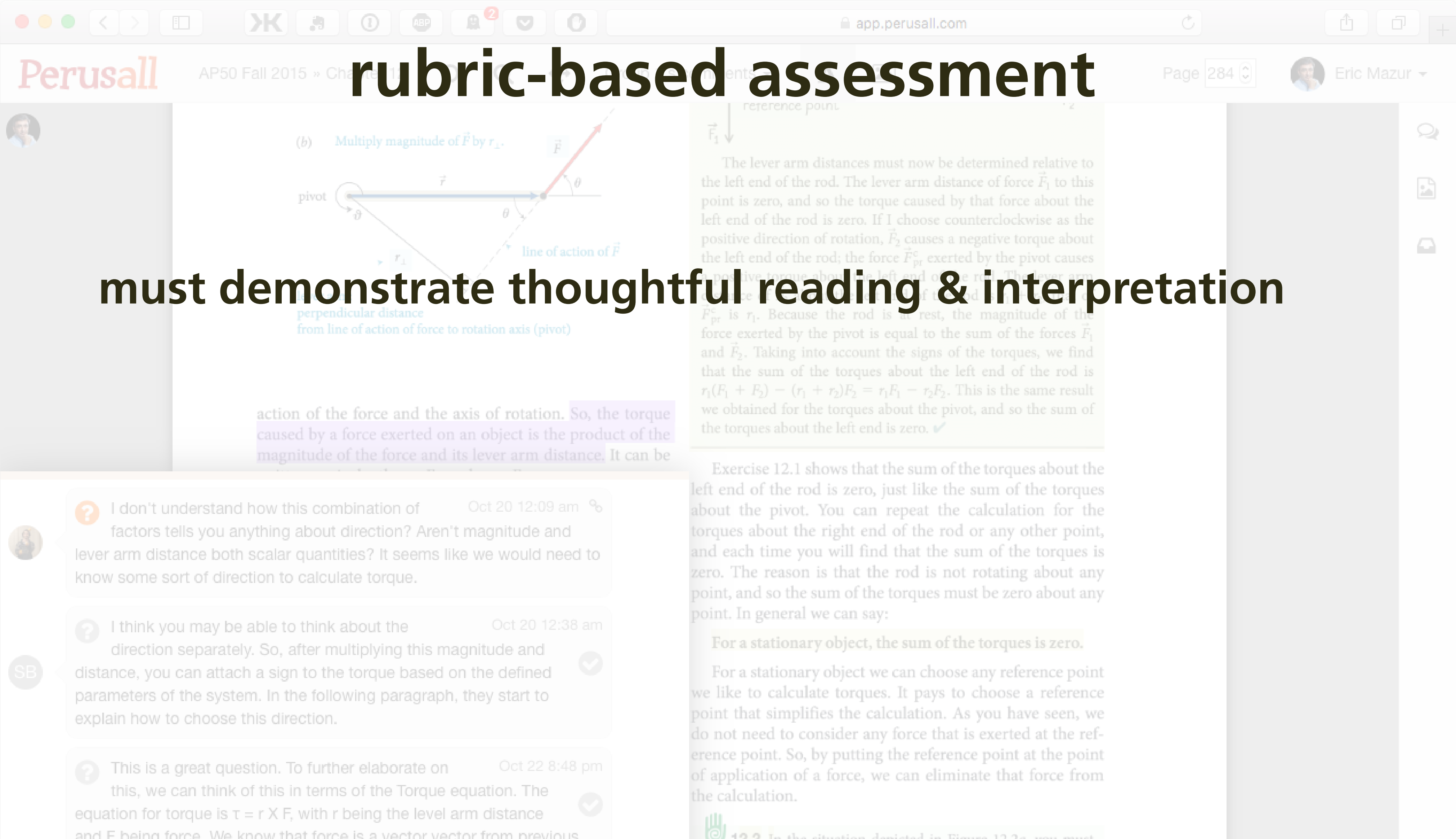


rubric-based assessment

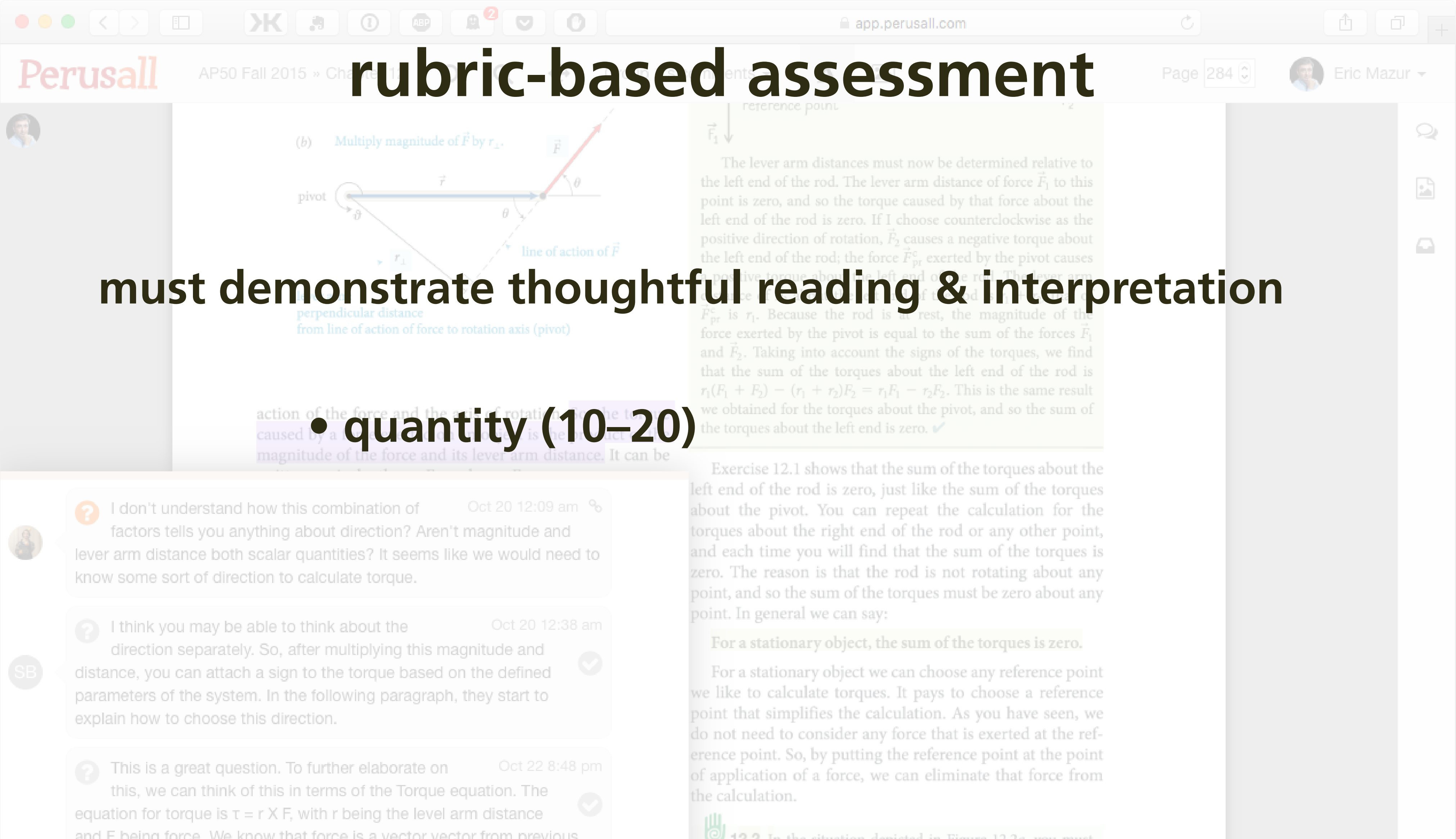


rubric-based assessment

must demonstrate thoughtful reading & interpretation



rubric-based assessment



must demonstrate thoughtful reading & interpretation

- quantity (10–20)

rubric-based assessment

must demonstrate thoughtful reading & interpretation

- quantity (10–20)
- timeliness (before class)

rubric-based assessment

must demonstrate thoughtful reading & interpretation

- quantity (10–20)
- timeliness (before class)
- distribution (not clustered)

rubric-based assessment

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

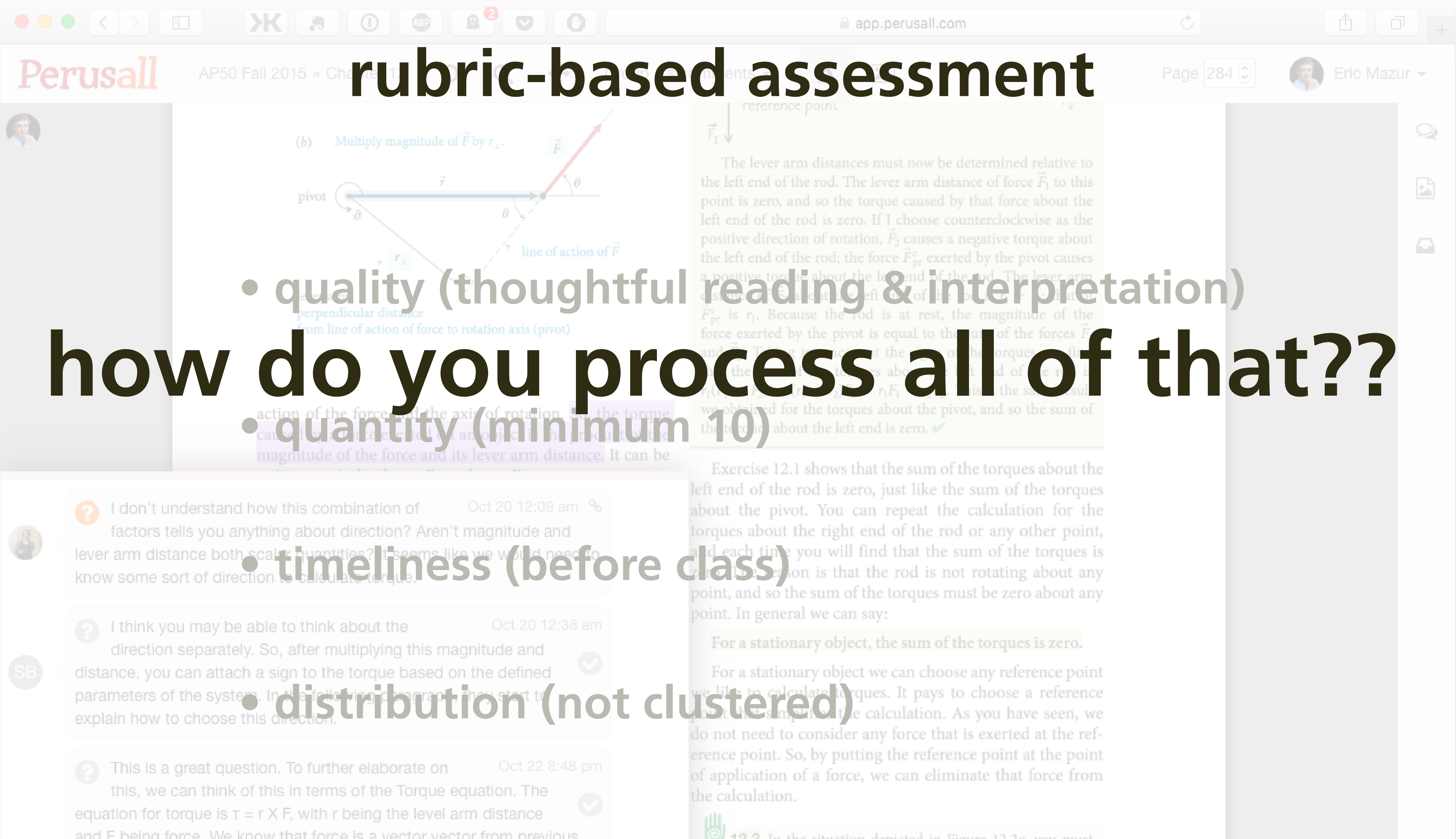
over 20,000 annotations!

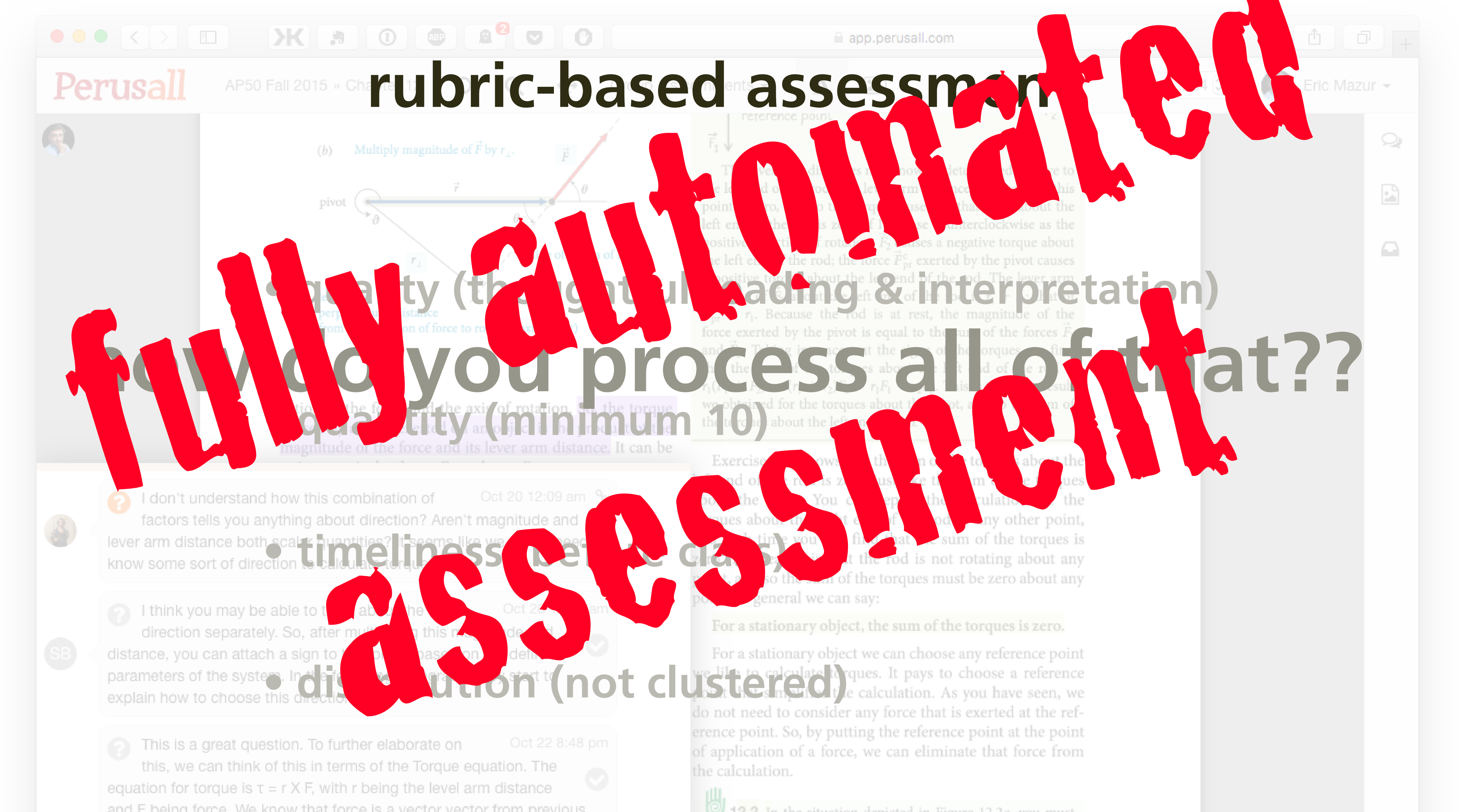
rubric-based assessment

- quality (thoughtful reading & interpretation)

how do you process all of that??

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




rubric-based assessment
• quality (thoughtful reading & interpretation)
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• timeliness (before class)
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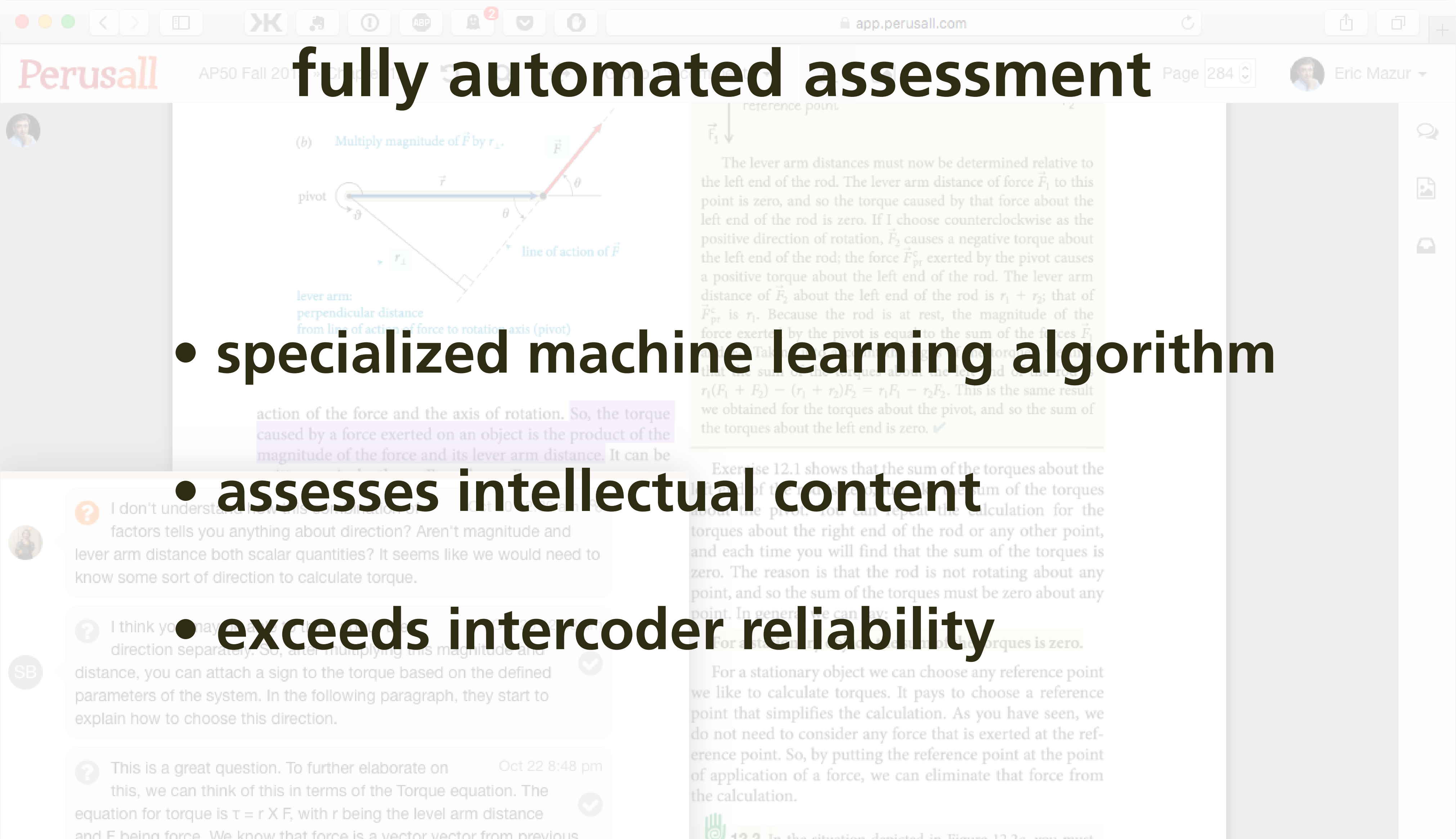
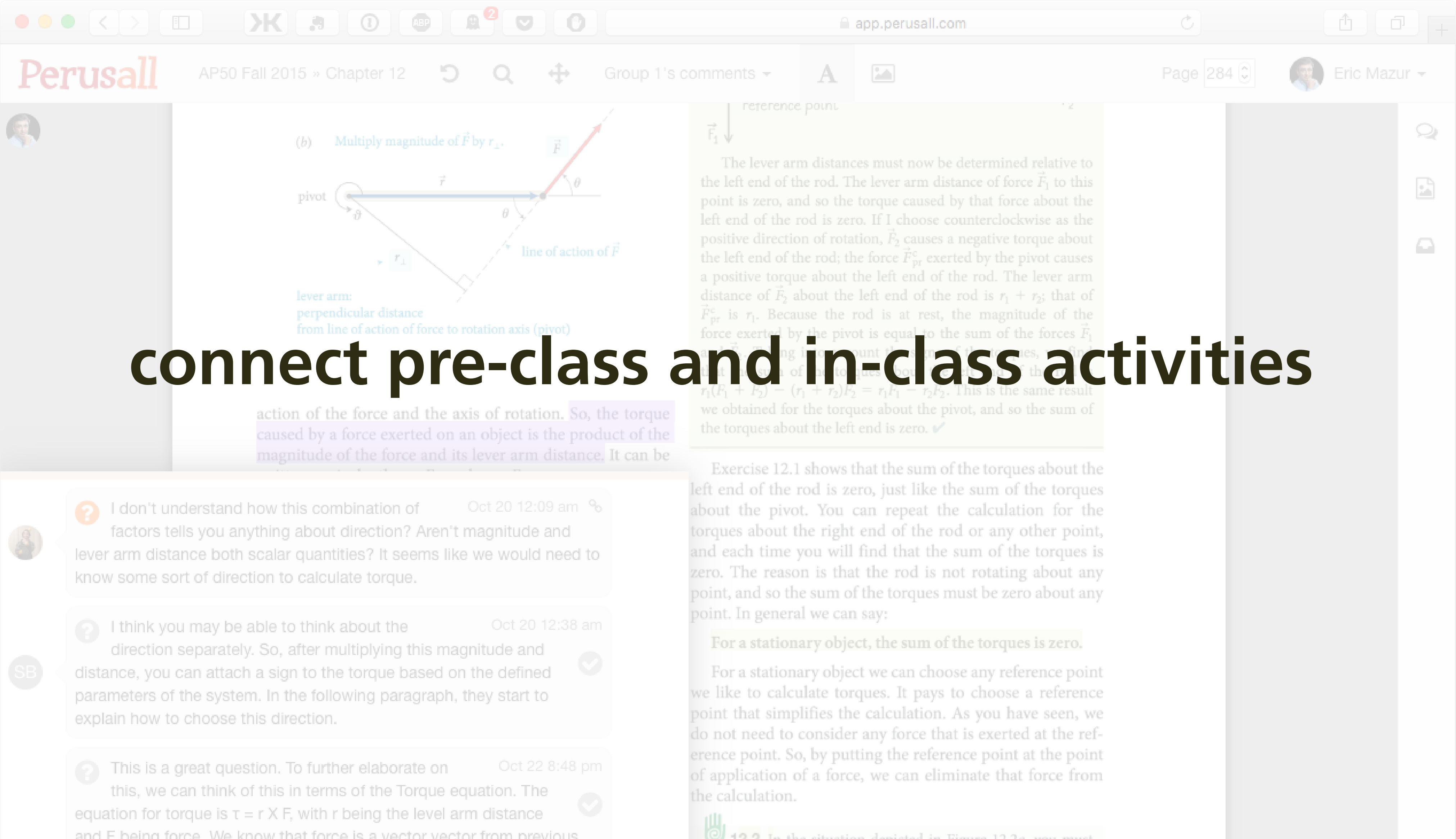
how do you process all of that??
fully automated assessment

fully automated assessment

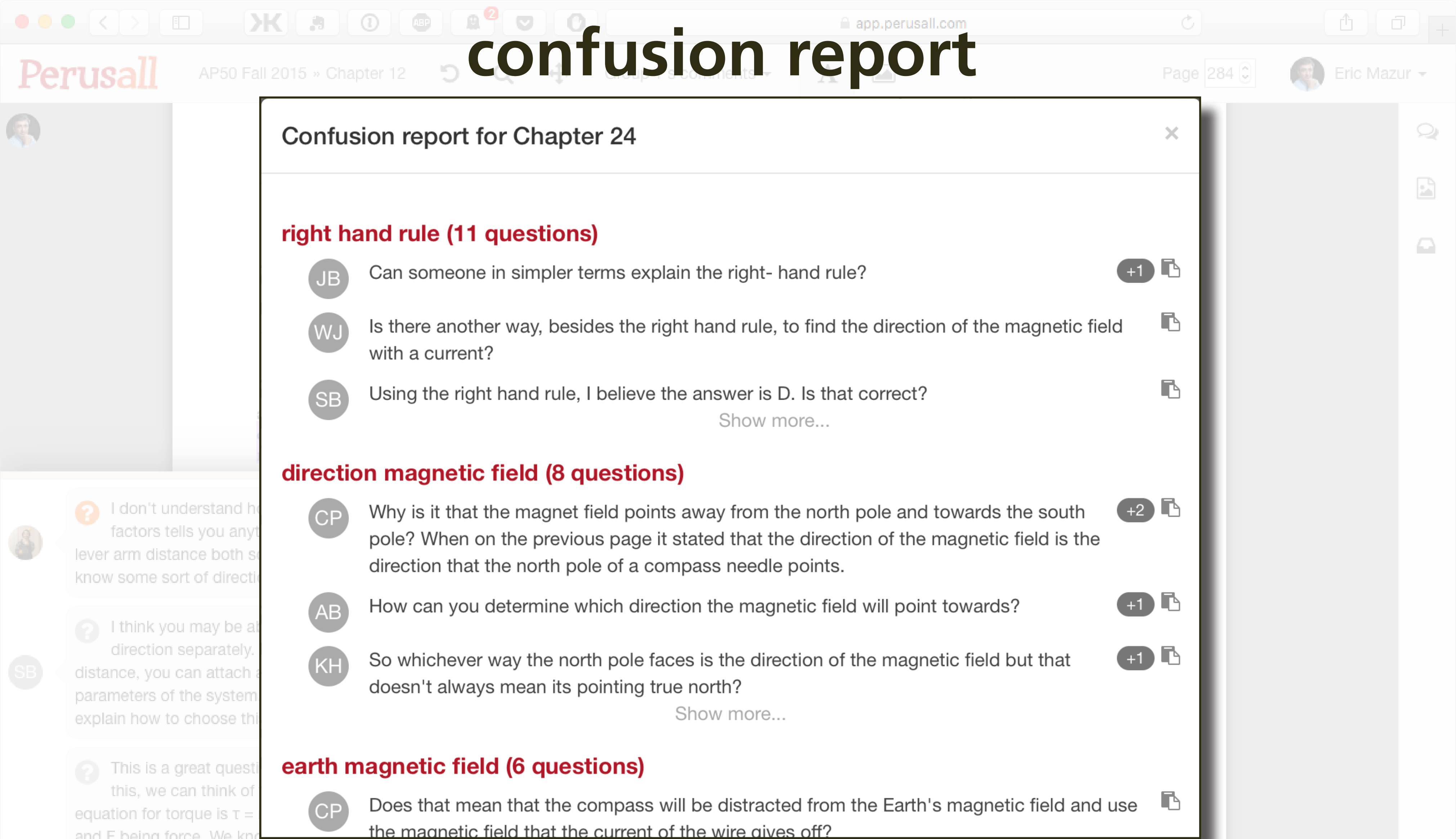


- specialized machine learning algorithm
- assesses intellectual content
- exceeds intercoder reliability

connect pre-class and in-class activities



confusion report



motivating factors

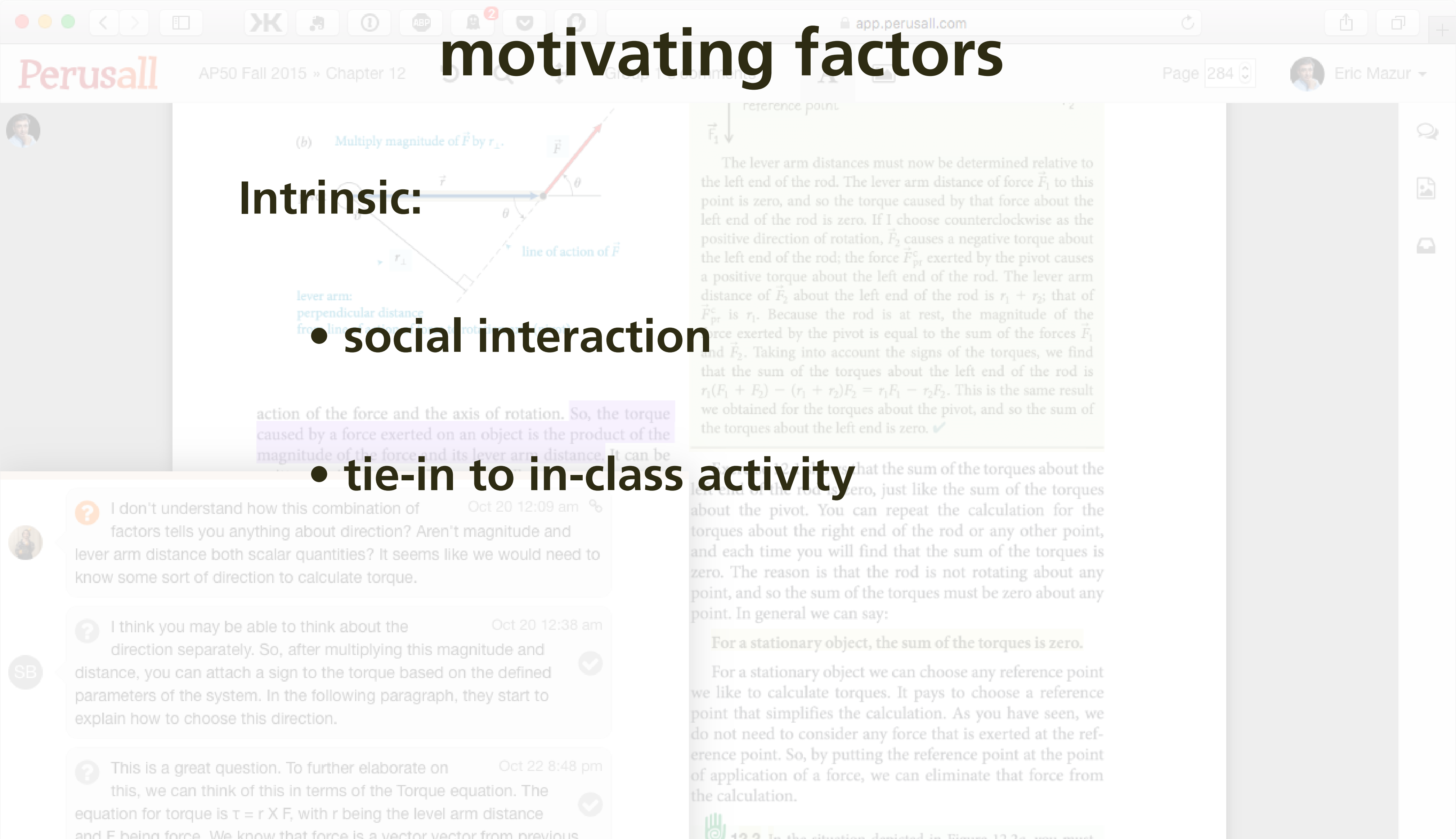
Intrinsic:

- social interaction

motivating factors

Intrinsic:

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



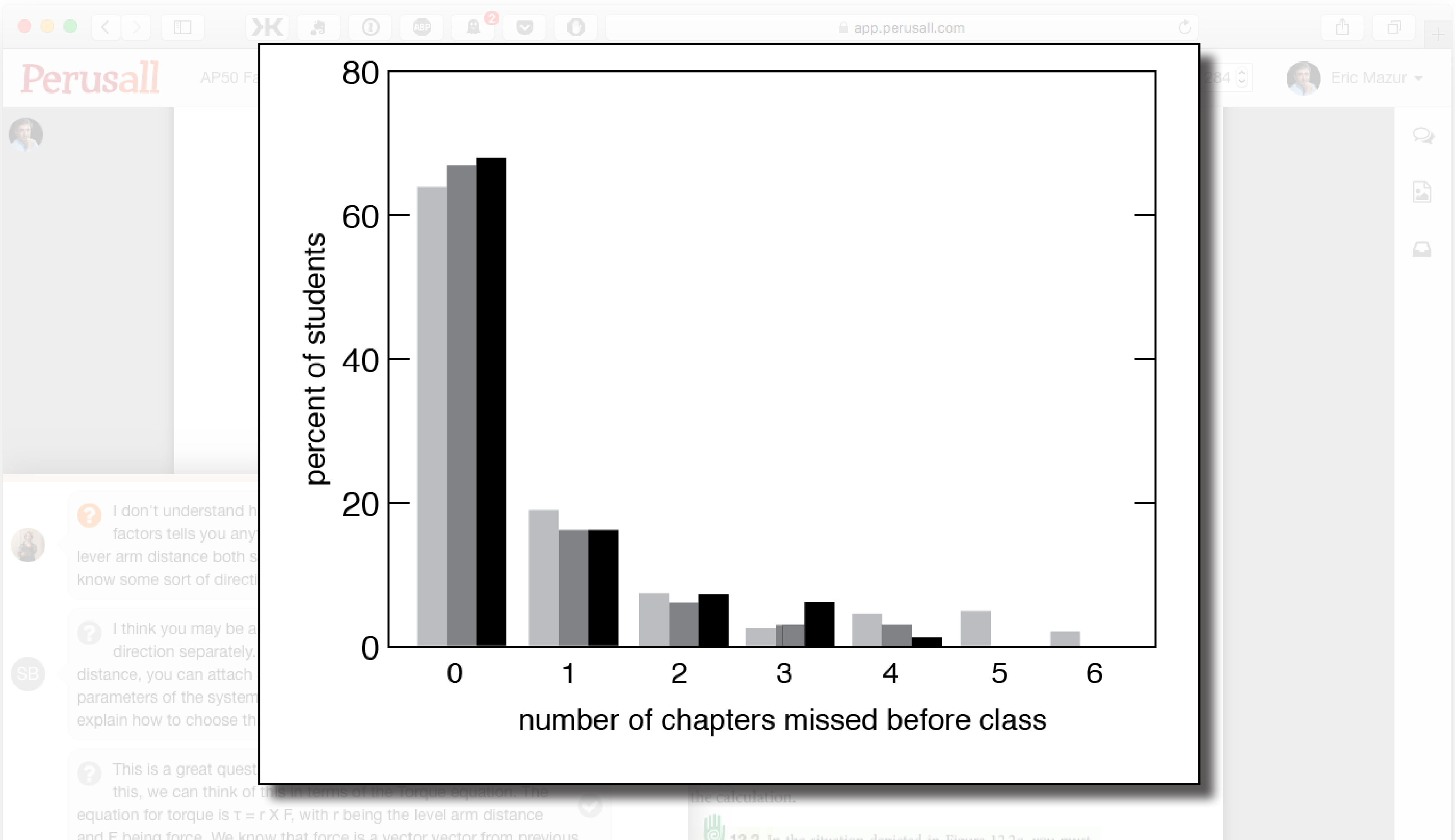
motivating factors

Intrinsic:

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

Extrinsic:

- assessment (fully automated)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80
60
40
20
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percent of students
0
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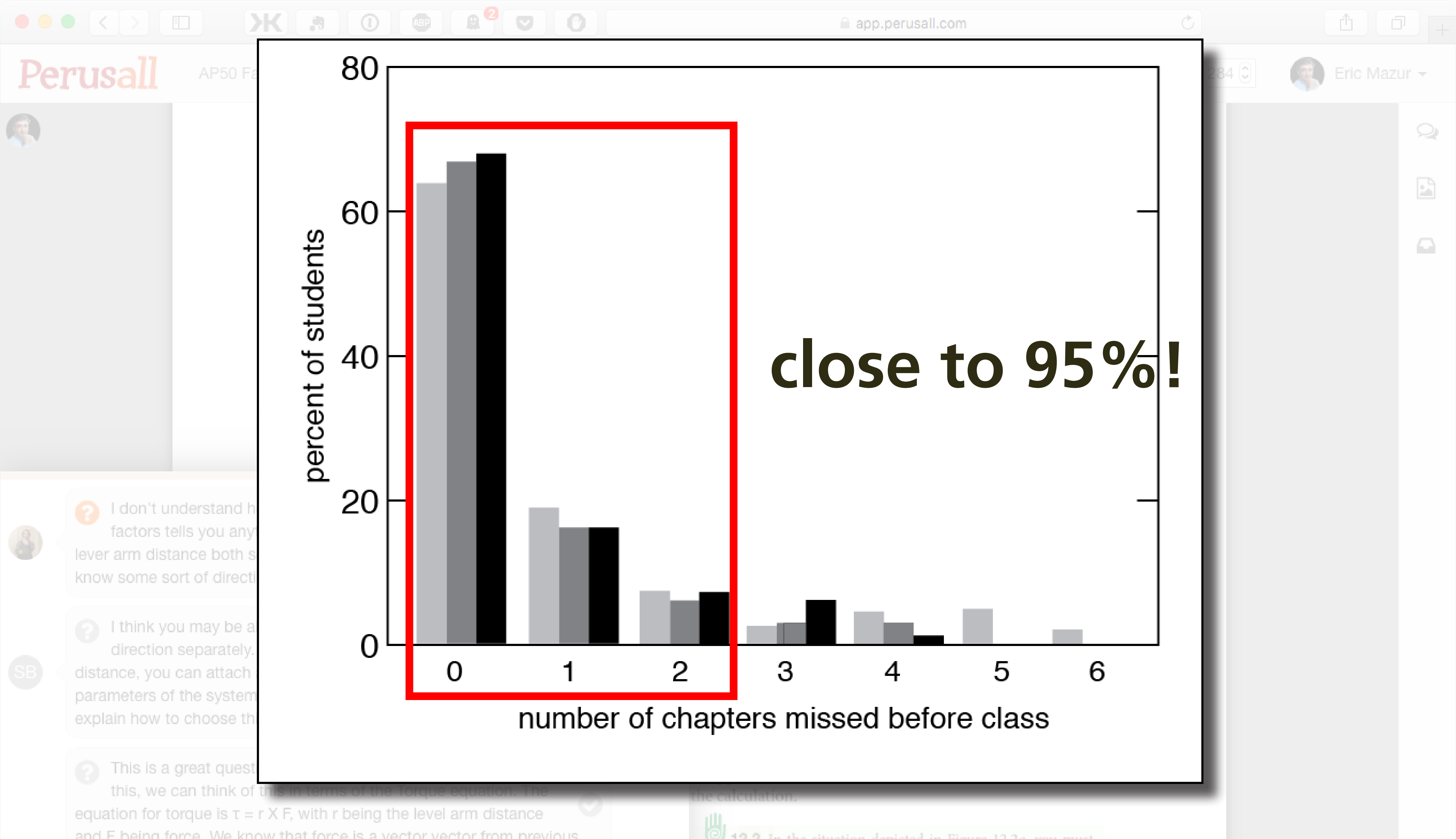
2
3
4
5
6
number of chapters missed before class



close to 95%!
percent of students
number of chapters missed before class
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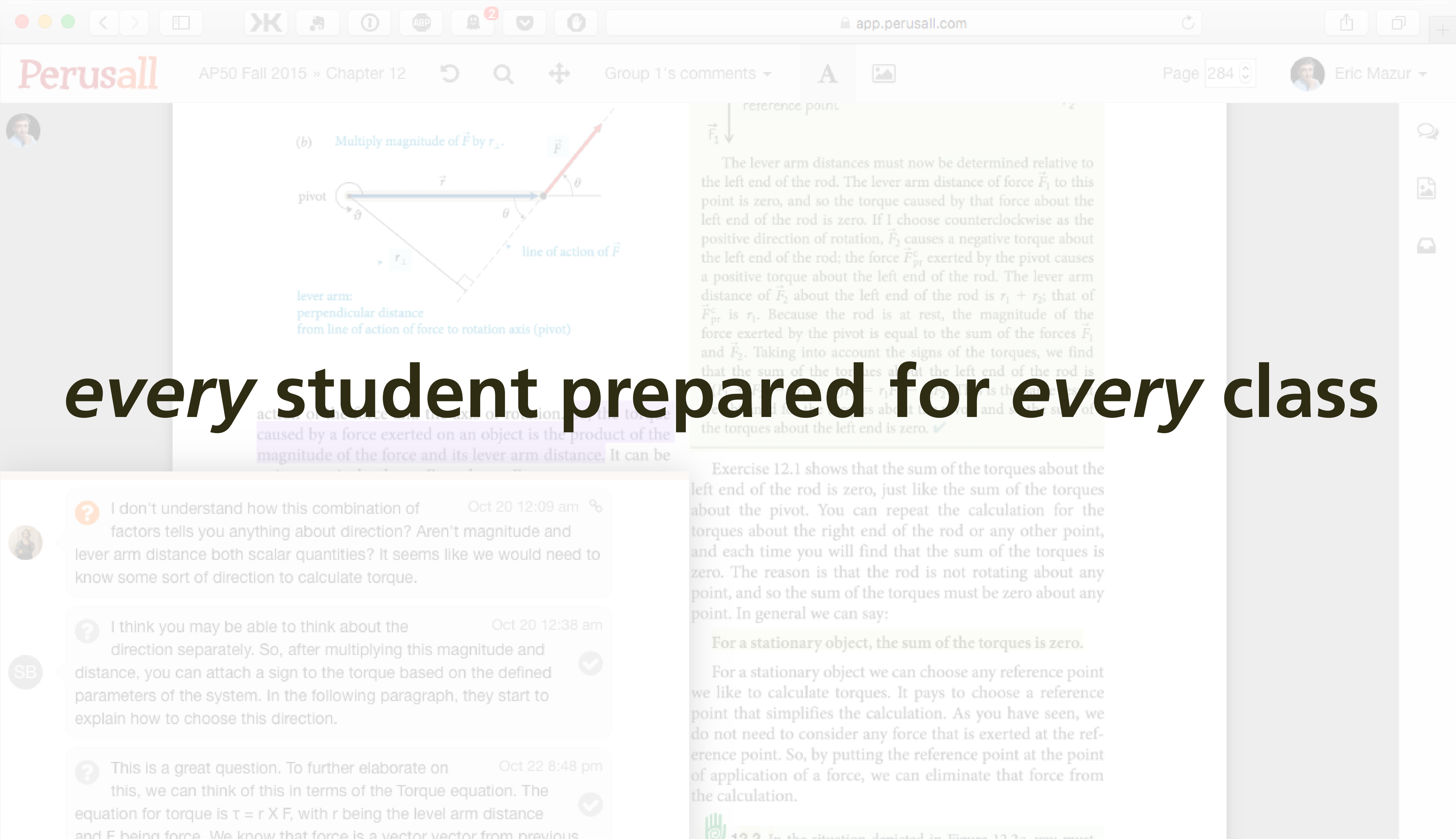
3
4
5
6


every student prepared for *every* class

Benefits

- virtually 100% completion of assignments
- improved use of class time

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- improved use of class time

all at no cost & without additional instructor effort!

Benefits

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Education is not just about:

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

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- transferring information
- getting students to do what we do

active participation/social interaction a must!

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