Flat space, deep learning

Yale-NUS
Singapore, 23 August 2016

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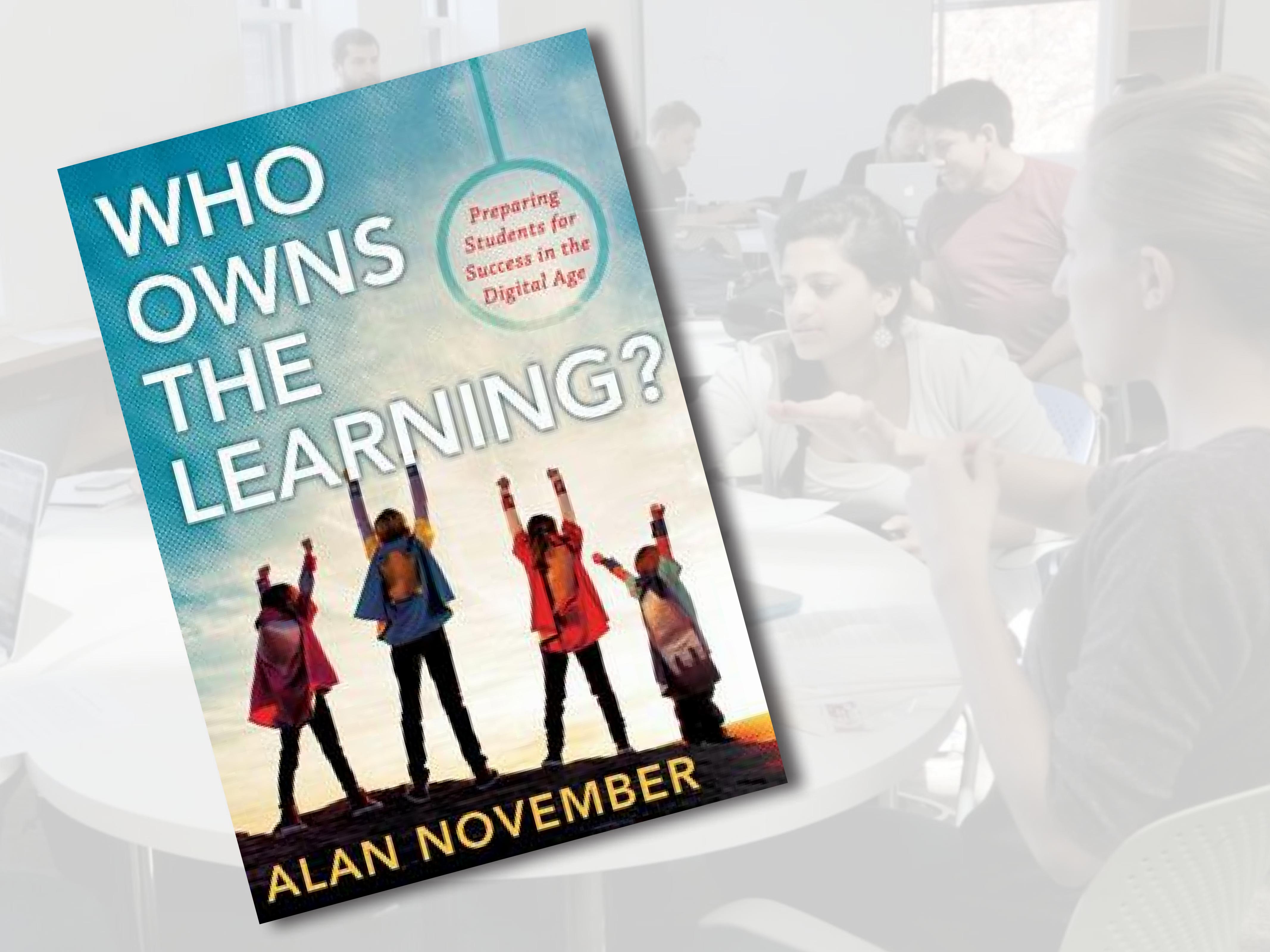
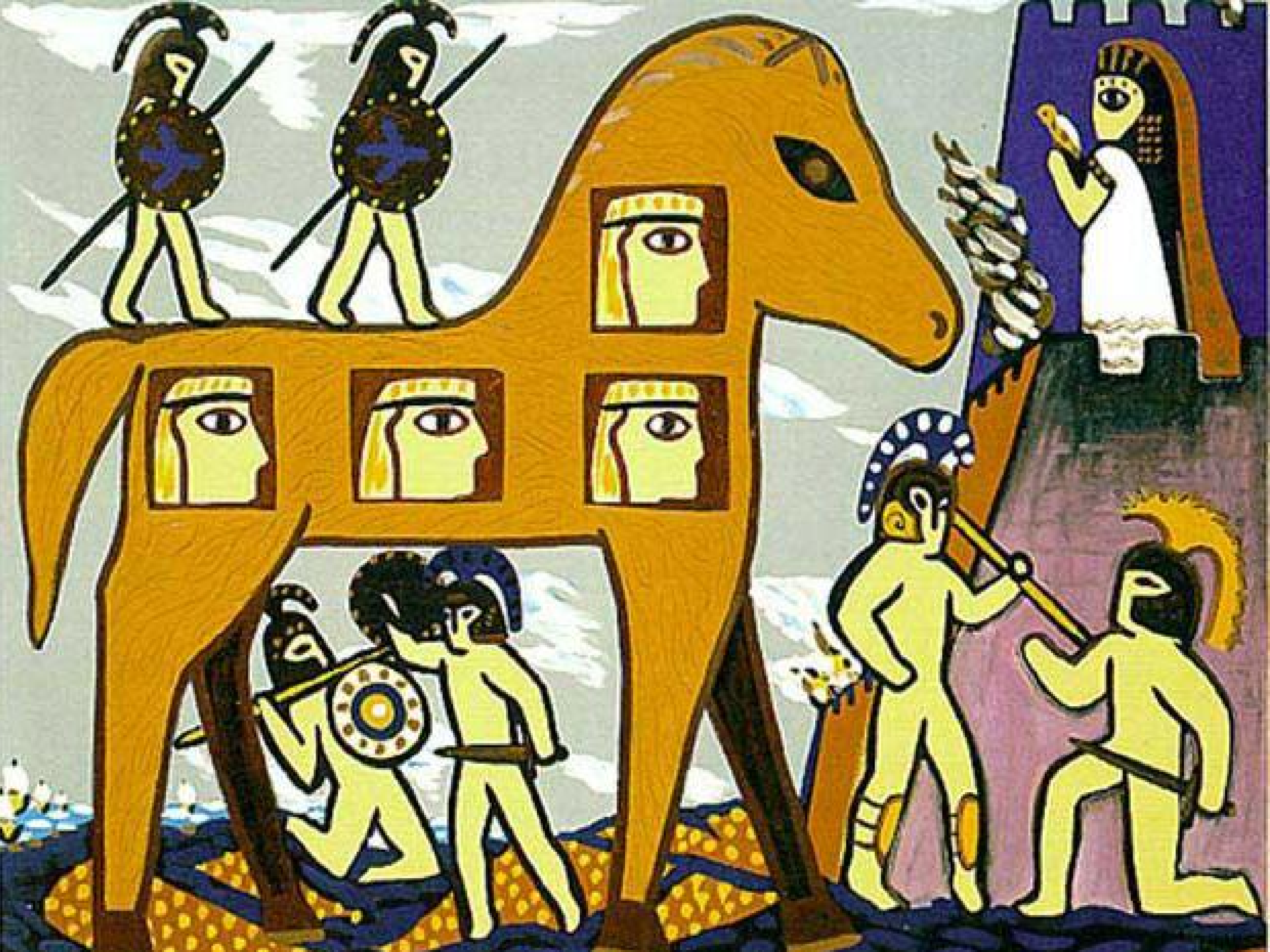
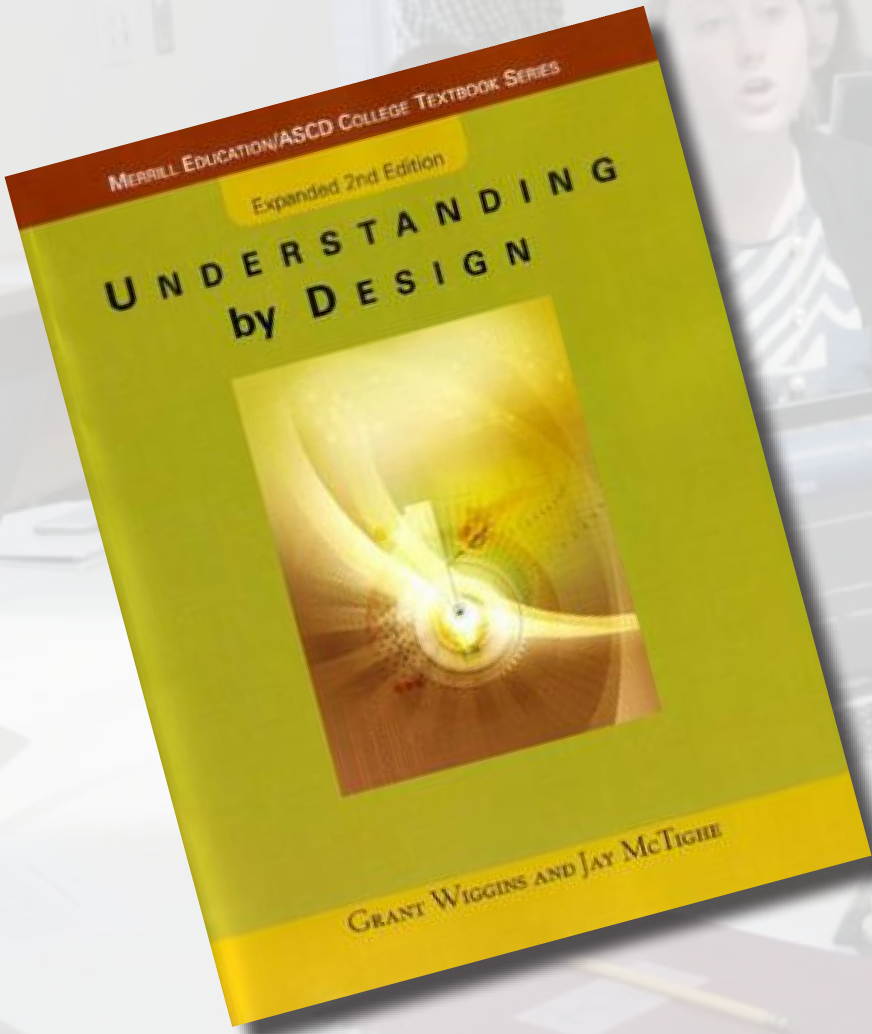

WHO OWNS THE LEARNING?
Preparing Students for Success in the Digital Age
ALAN NOVEMBER

Ownership of learning *physics*?



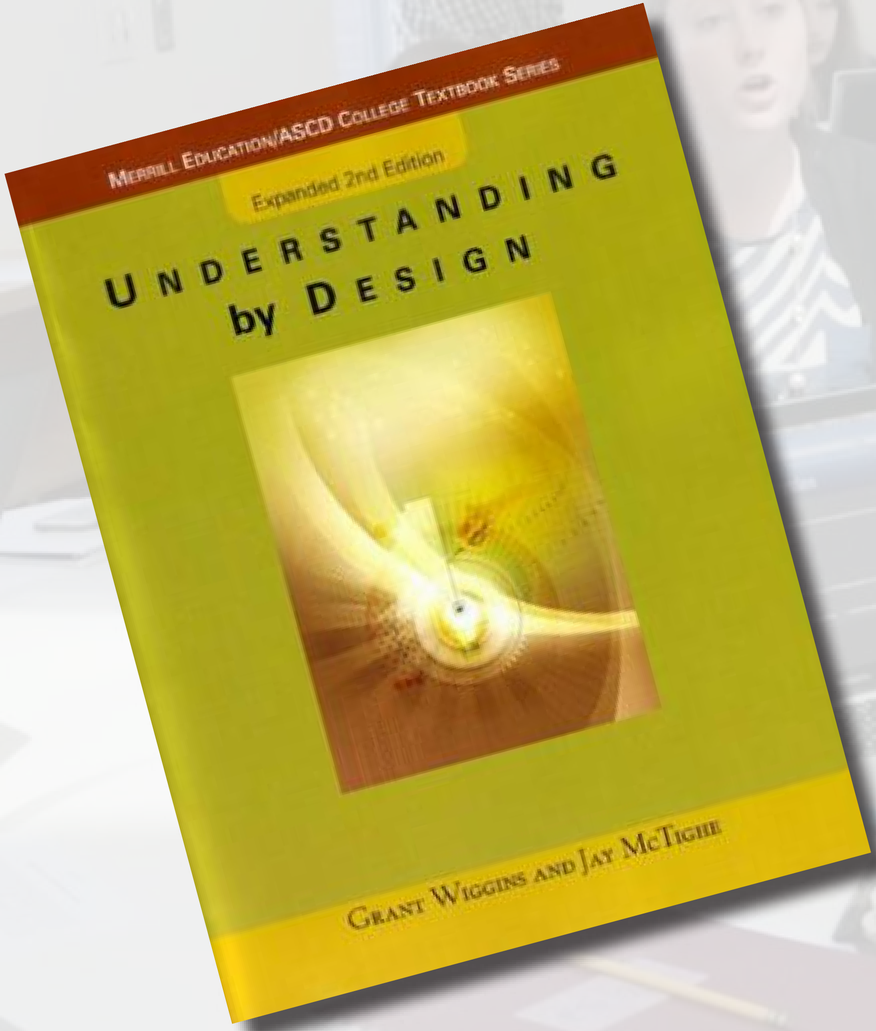
team & project-based approach

Setting learning goals



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

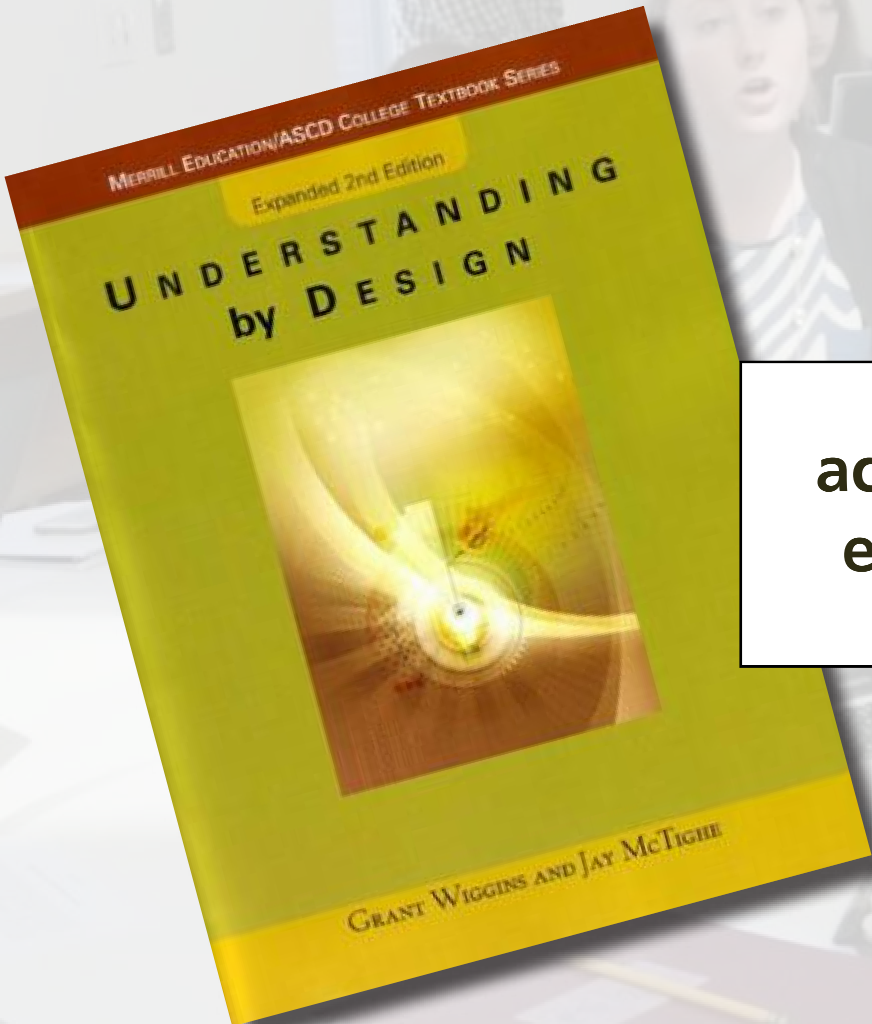
Backward design



desired outcomes

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

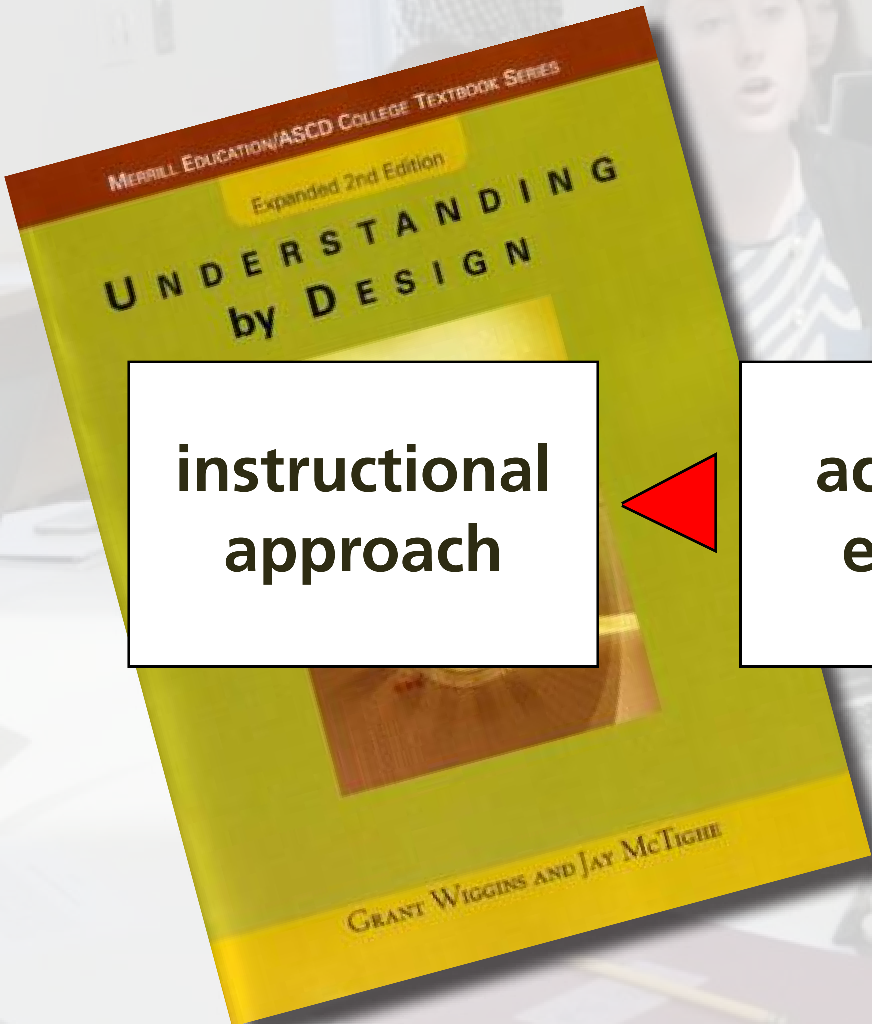
Backward design



acceptable evidence ◄ **desired outcomes**

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

Backward design



instructional approach ◀ acceptable evidence ◀ desired outcomes

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

competencies

conveying [illegible]

[illegible] professionalism in your conduct [illegible]

- acting in a manner that is respectful to your [illegible]
- being punctual and participating fully in all classroom activ[illegible]
- taking decisions and executing actions that are fair and honest, and that [illegible] standards of conduct.

[illegible] activities in AP50 are designed to contribute to the development of the followin[illegible]

- **Qualitative Analysis**: The ability to analyze and solve problems in scien[illegible] disciplines qualitatively, including estimation, analysis with uncertainty [illegible] visual thinking.
- **Quantitative Analysis**: The ability to analyze and to solve problems in [illegible] disciplines quantitatively, including use of appropriate tools, quantita[illegible] solving, and experimentation.
- **Diagnosis:** The ability to identify and resolve problems within [illegible] identification, formation and testing of a hypothesis, and recommen[illegible]
- **Design:** The ability to develop creative, effective designs that [illegible] creation, problem formulation, application of other competencies [illegible] [illegible] integrate knowledge, beliefs and modes of inquiry from [illegible] [illegible] to contribute effectively in a variety of [illegible] [illegible]ntributions. You will develo[illegible] [illegible] approaches and [illegible]

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...
   - applying your knowledge of physics to solve problems
   - ...ing data, analyzing, and interpreting them

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

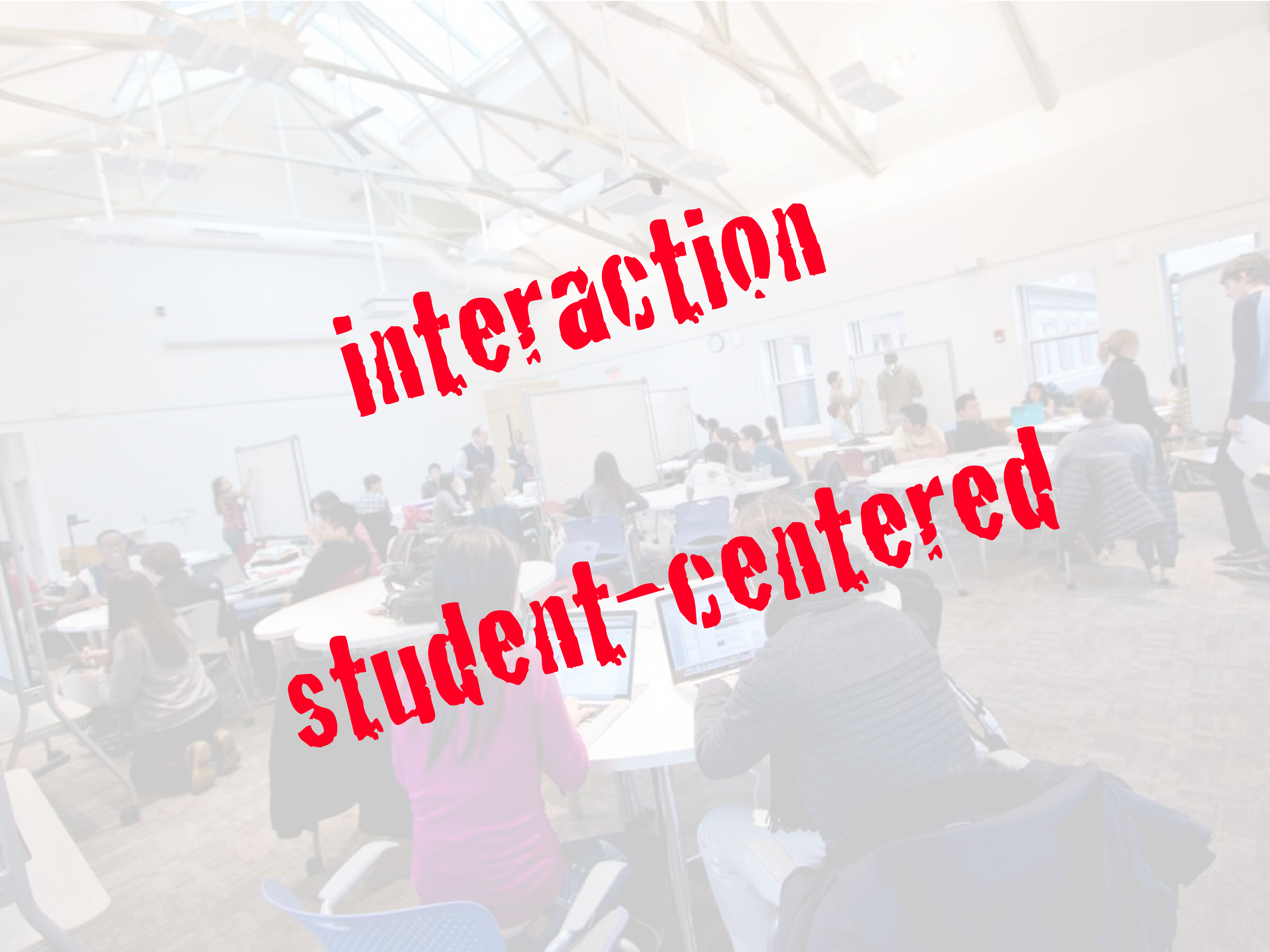
content-specific goals

http://bit.ly/ap50visitor

raction...

- ...nduct fundamental experiments ...
- ...ectrostatic interaction and the two types of cha...
- ...xplain quantization and conservation of charge.
- Describe the observations supporting the quantization and conservation of...
- Define and give examples of insulators and conductors.
- Describe how the charge carriers behave in insulators and conductors.
- Explain polarization and how it gives rise to an electric force on a neutral obje...
- Describe what happens on the atomic level when a conductor (insulator) is p...
- Describe and explain the process of charging by induction.
- Use Coulomb's law to calculate or estimate the electric force that a given c... distribution, exerts on a charged particle.
- Explain the conditions in which Coulomb's law is valid.
- Explain what a field is and give examples of scalar and vector fields.
- Draw vector field diagrams for a simple distribution of charged particle...
- Describe a vector field by means of vector diagrams and vector functio...
- ...d explain the electric field.
- ...between the electric field concept and the ins...
- ...determine the e...


information transfer
faculty-centered


interaction
student-centered


no lectures
no exams


CLASS
ROOM
1st exposure
deeper understanding


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

1 information transfer

1 information transfer

2 projects

CLASS

1st exposure

ROOM

deeper understanding

ROOM

1st exposure

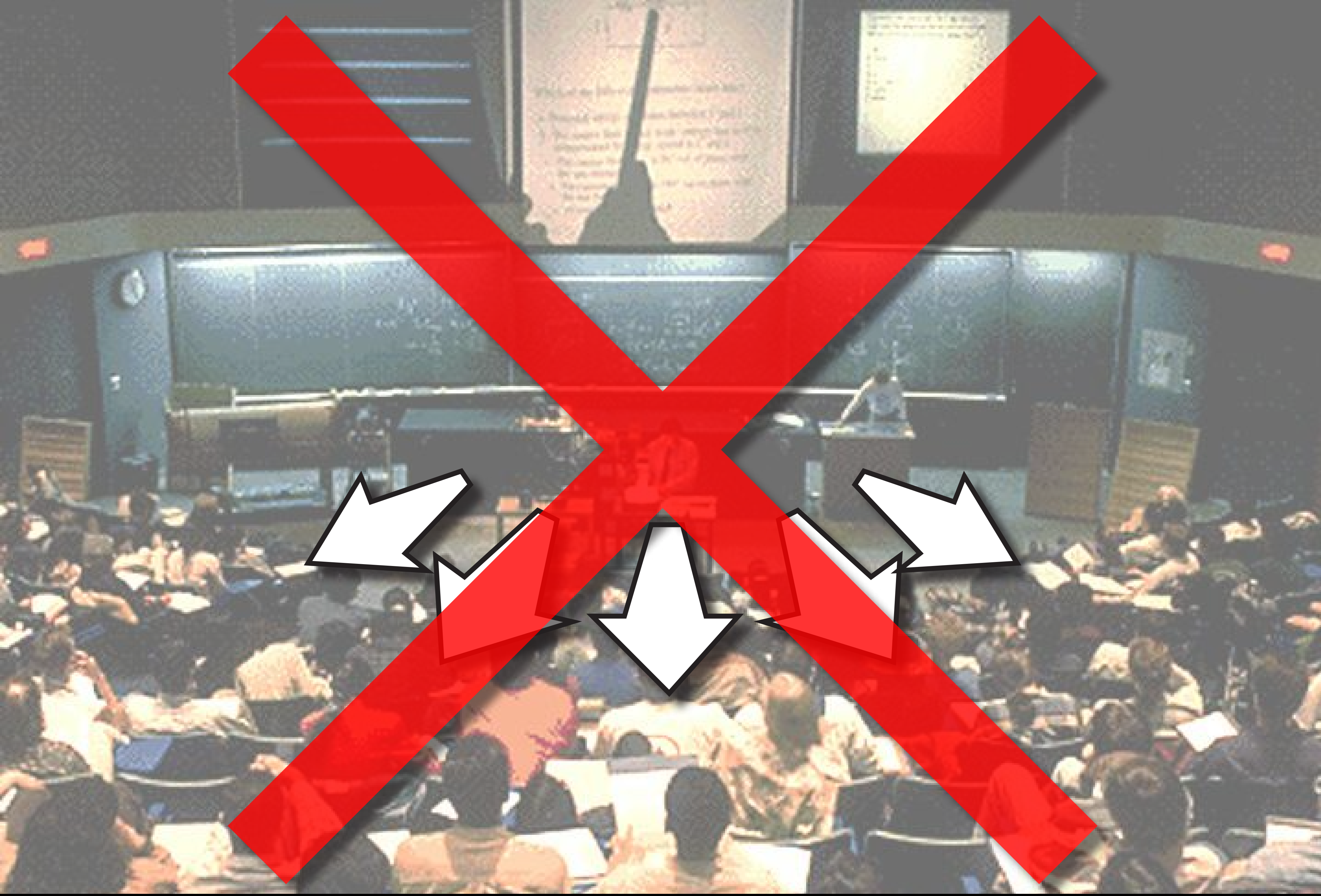
CLASS

deeper understanding

1 information transfer

2 projects

3 in-class activities

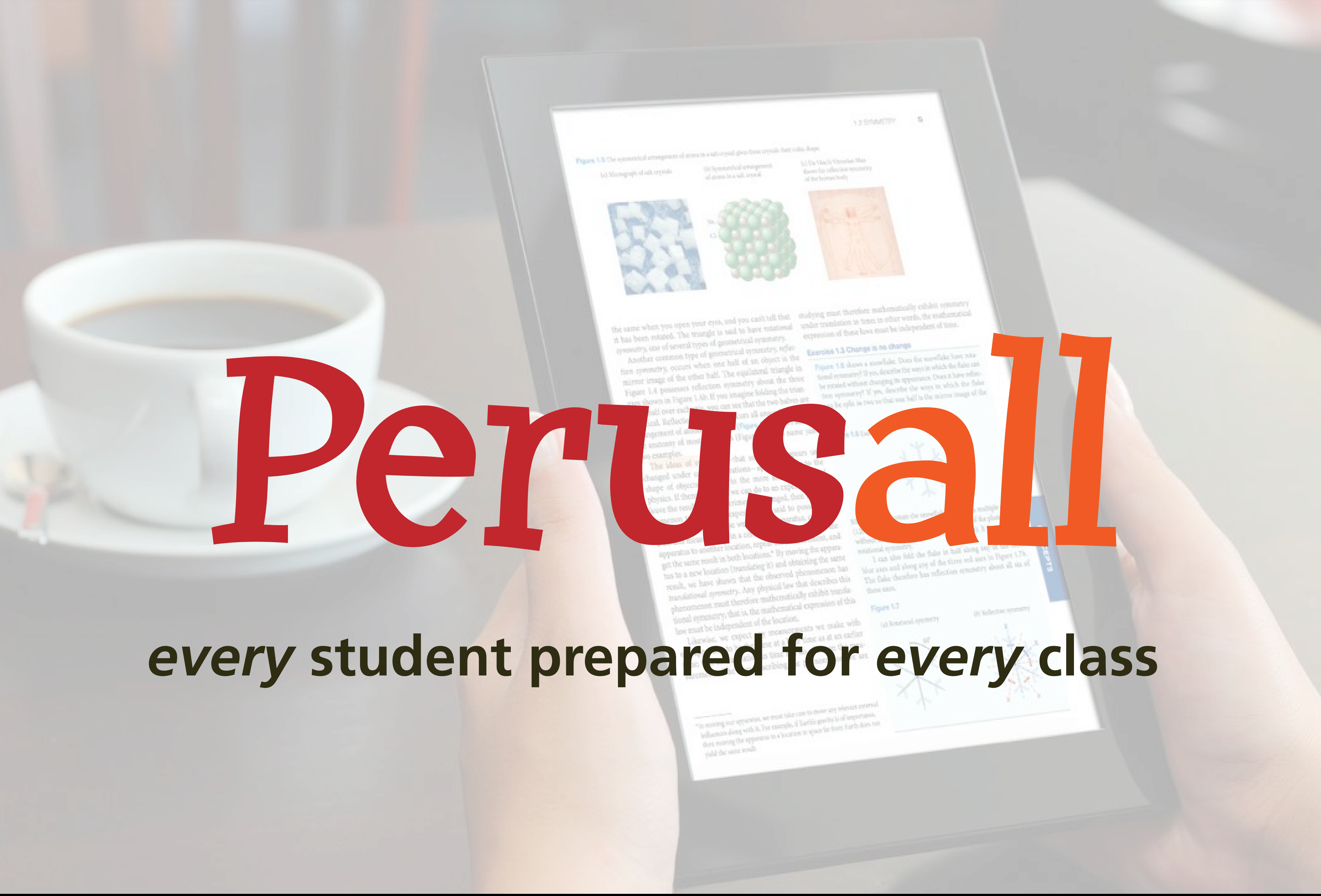


❶ information transfer

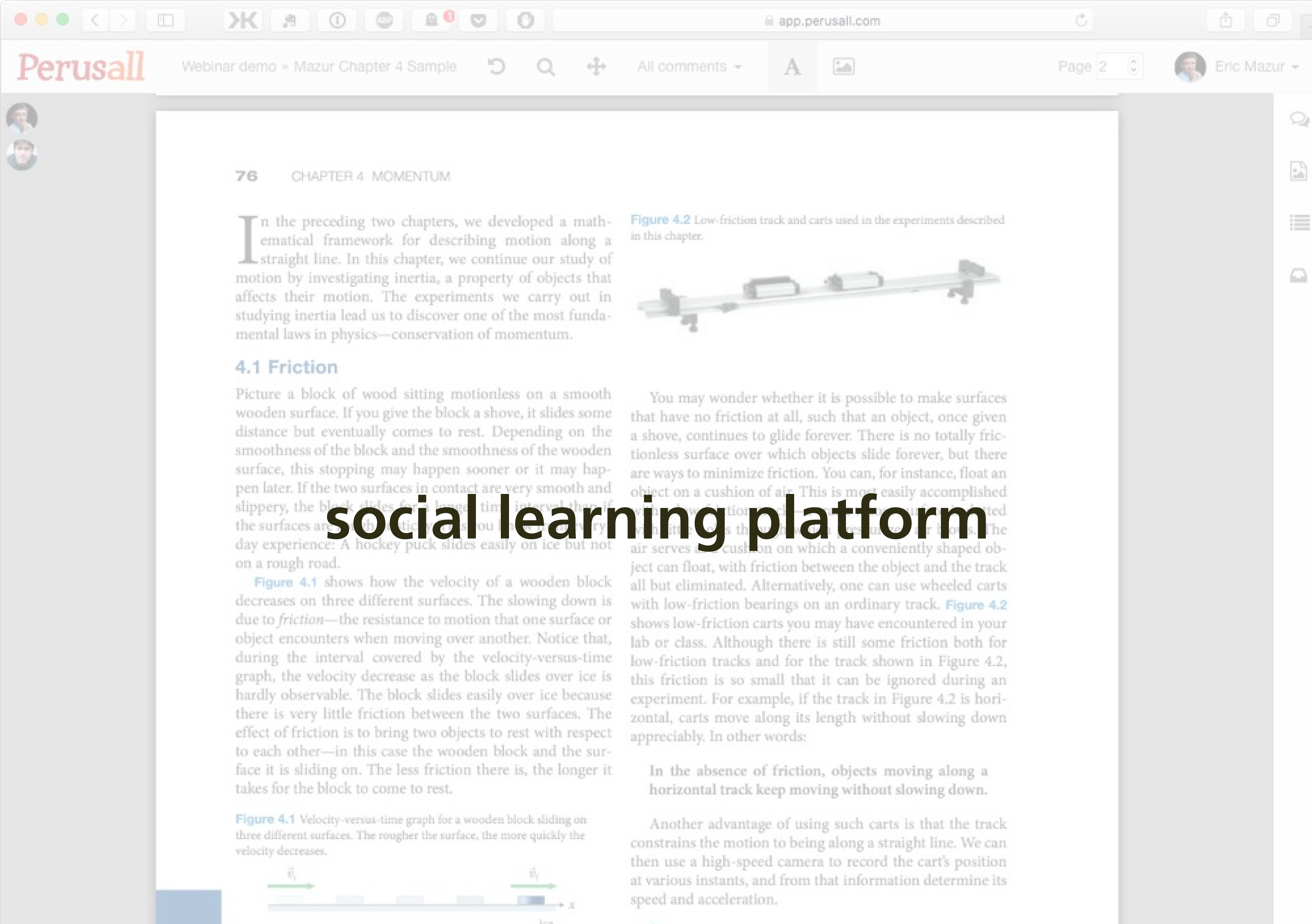
Solution

turn out-of-class component

also into a social interaction!



1 information transfer



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

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

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

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

You may wonder whether it is possible to make surfaces that have no friction at all, such that an object, once given a shove, continues to glide forever. There is no totally frictionless surface over which objects slide forever, but there are ways to minimize friction. You can, for instance, float an object on a cushion of air. This is most easily accomplished [illegible] 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.

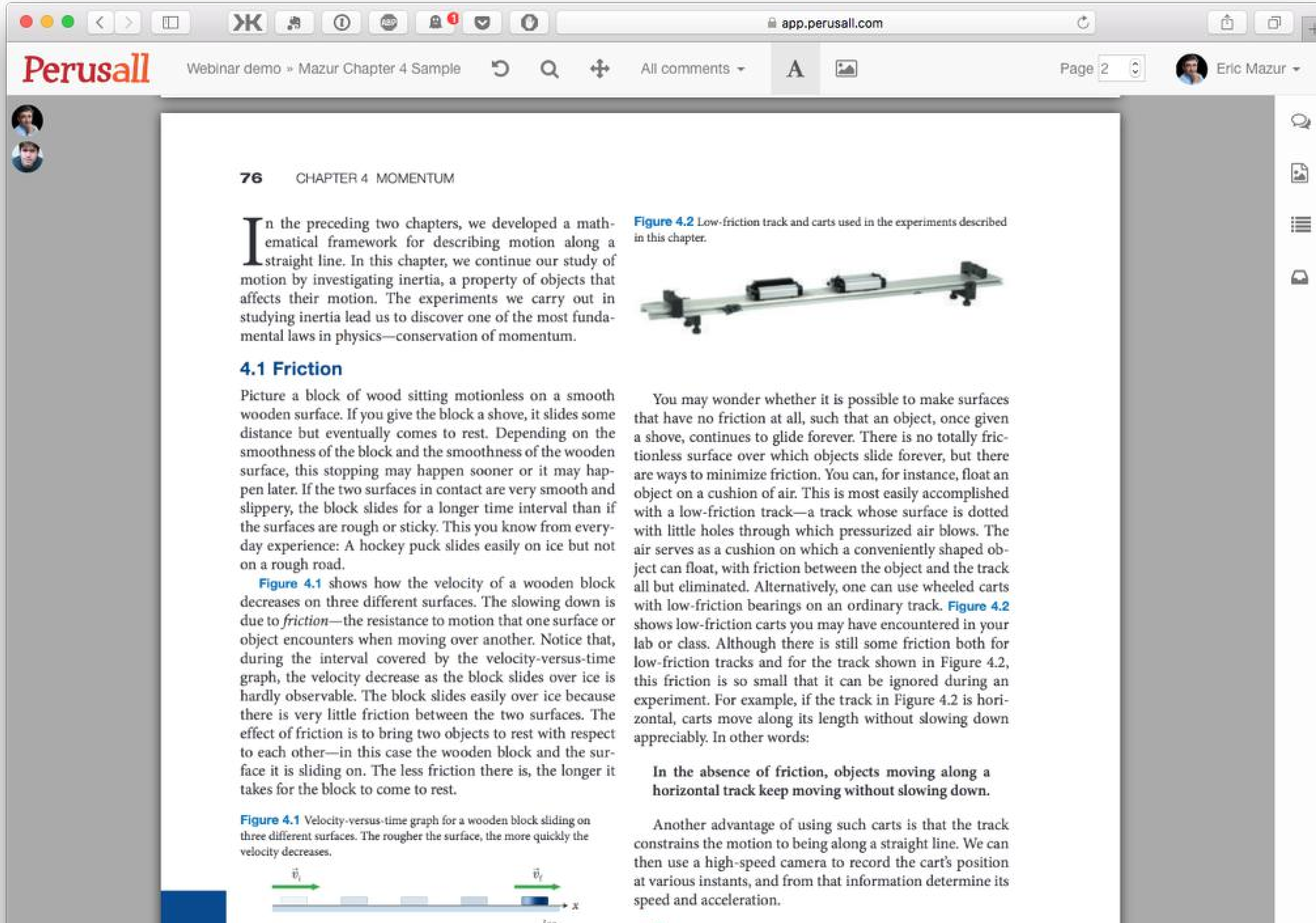
Another advantage of using such carts is that the track constrains the motion to being along a straight line. We can then use a high-speed camera to record the cart's position at various instants, and from that information determine its speed and acceleration.

social learning platform

1 information transfer

1 design

2 approach



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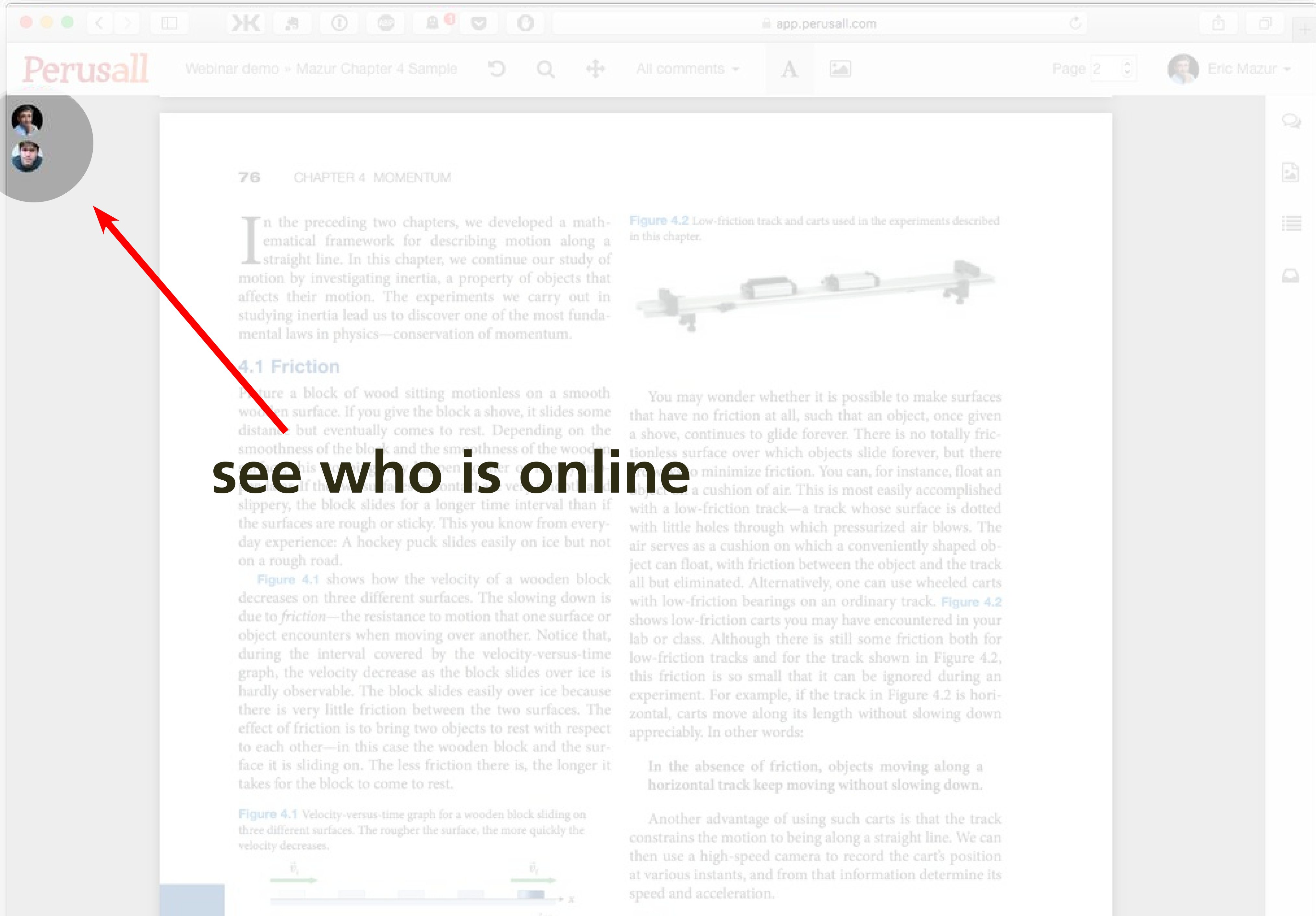
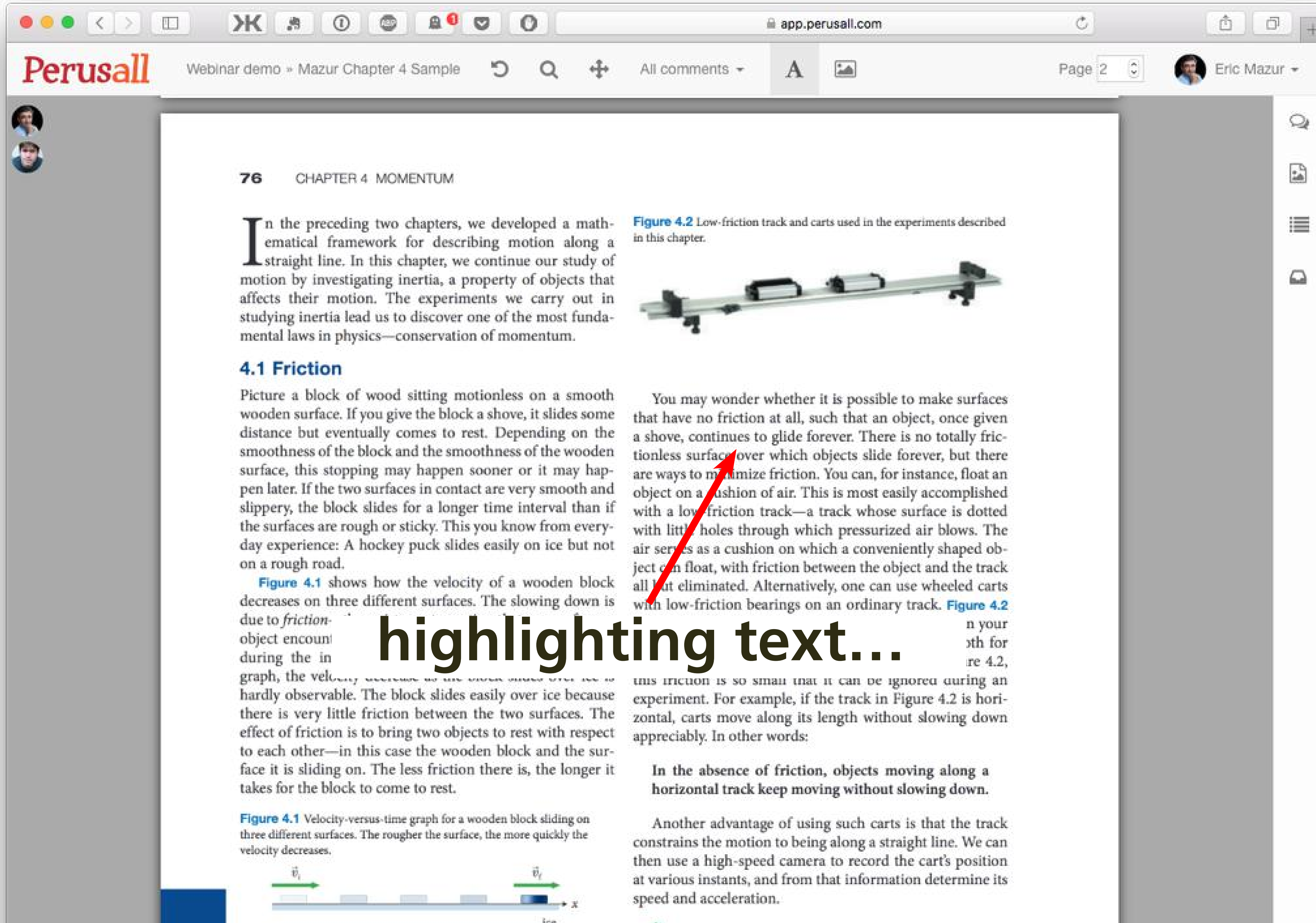
1 information transfer



1 information transfer



76 CHAPTER 4 MOMENTUM

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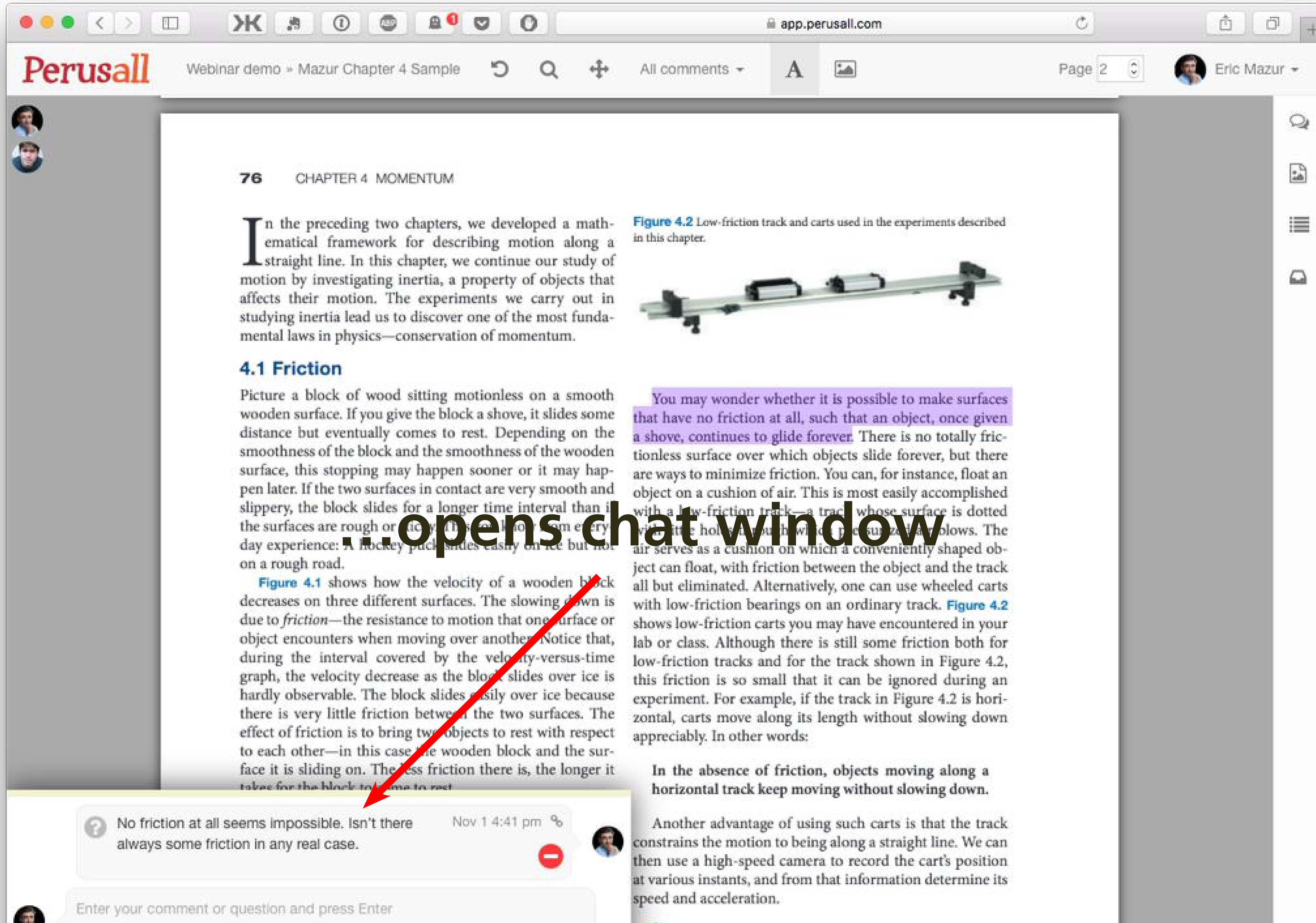
highlighting text…

1 information transfer



1 information transfer

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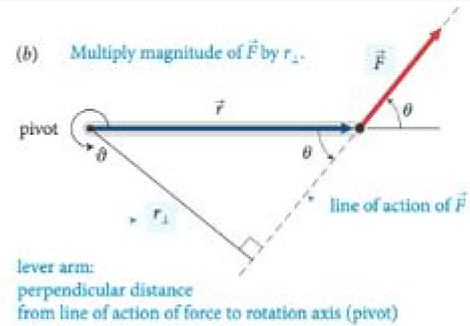
Perusall AP50 Fall 2015 » Chapter 12 Group 1's comments Page 284 Eric Mazur



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

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

CONCEPTS

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.

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.

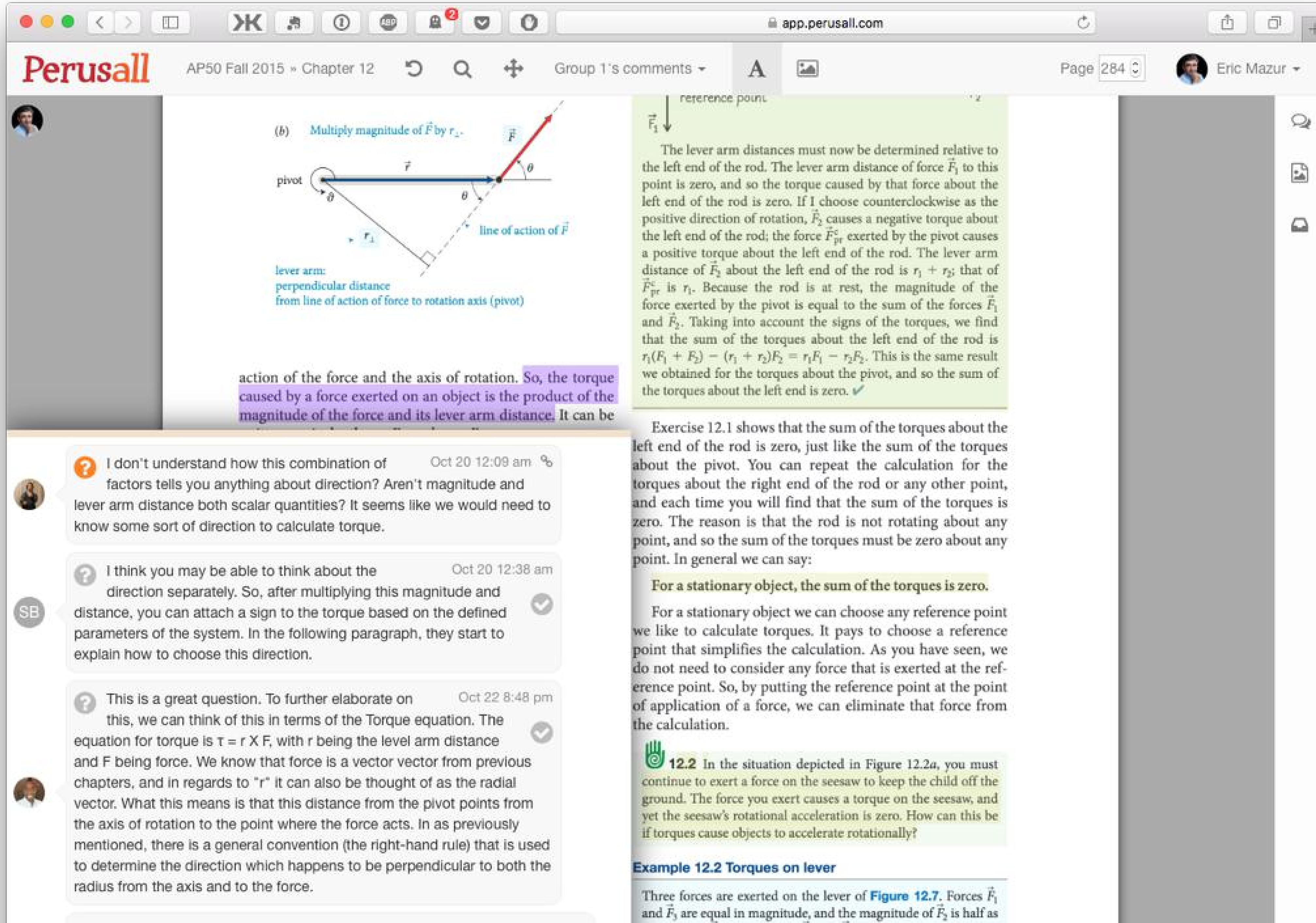
For a stationary object we can choose any reference point we like to calculate torques. It pays to choose a reference point that simplifies the calculation. As you have seen, we do not need to consider any force that is exerted at the reference point. So, by putting the reference point at the point of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

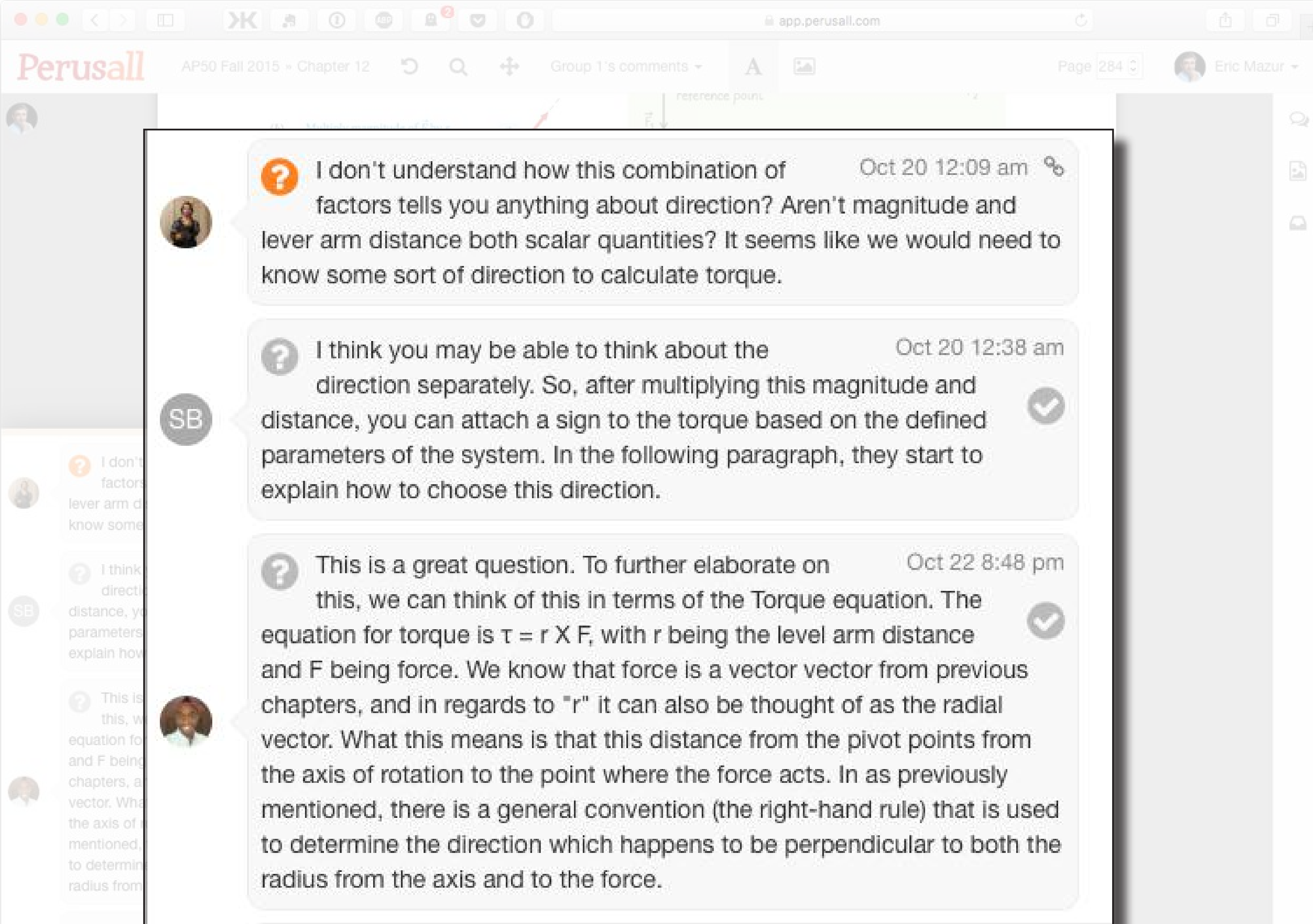
Example 12.2 Torques on lever

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 information transfer



1 information transfer



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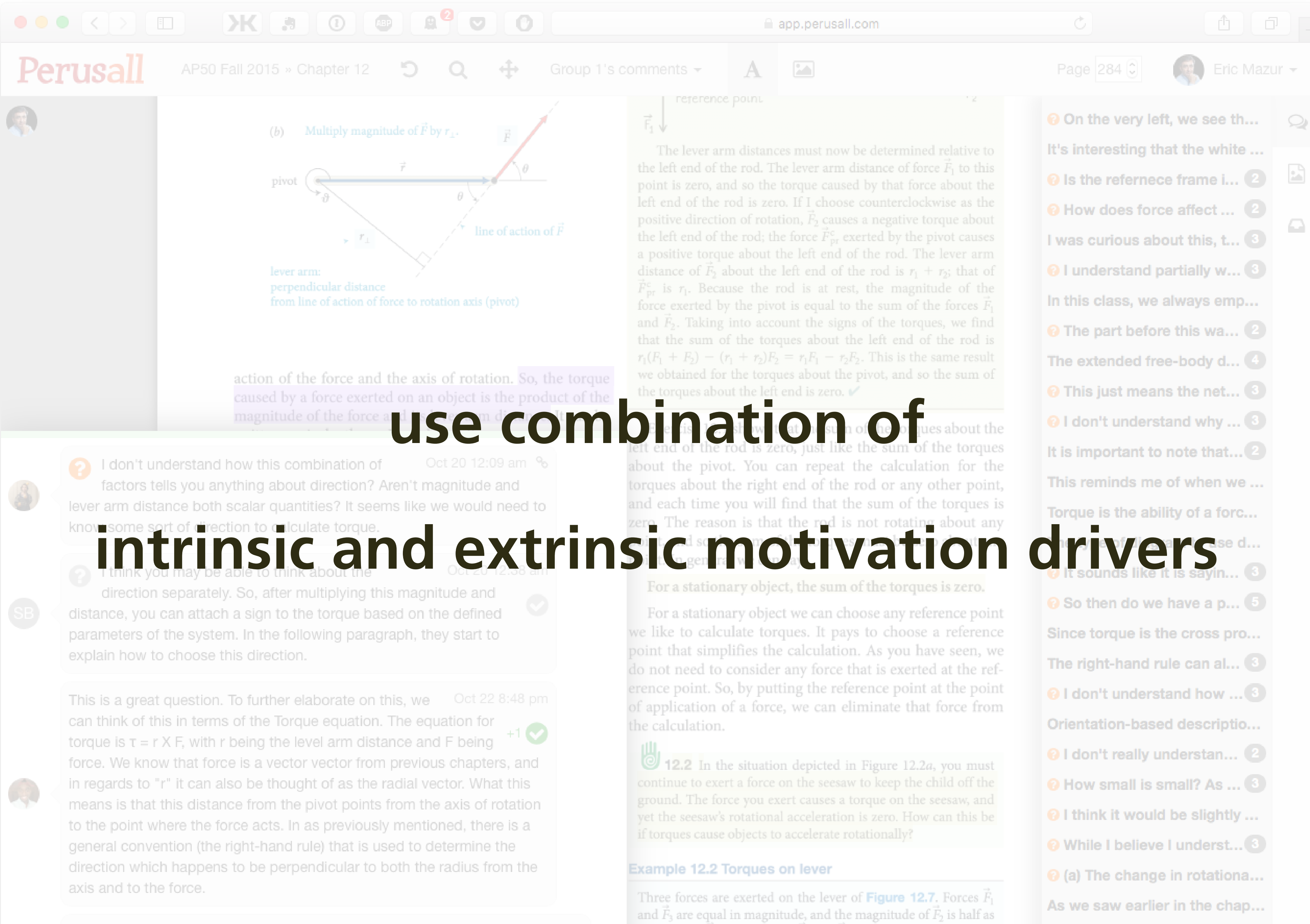


use combination of

intrinsic and extrinsic motivation drivers

1 information transfer

rubric-based assessment

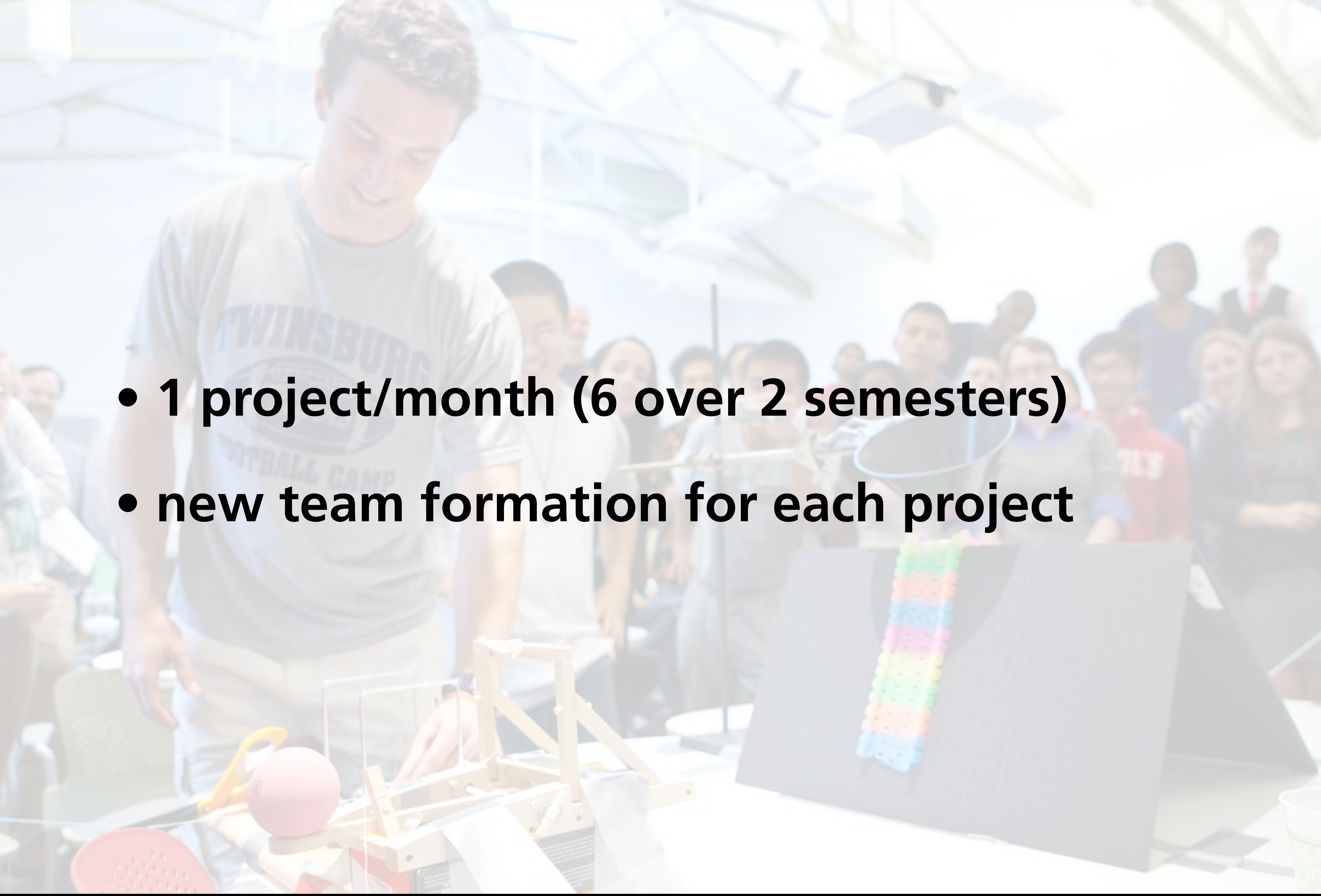
- quality (thoughtful reading & interpretation)
- quantity (minimum ...)
- timeliness (before class)
- distribution (not clustered)

over 20,000 annotations!

❶ information transfer

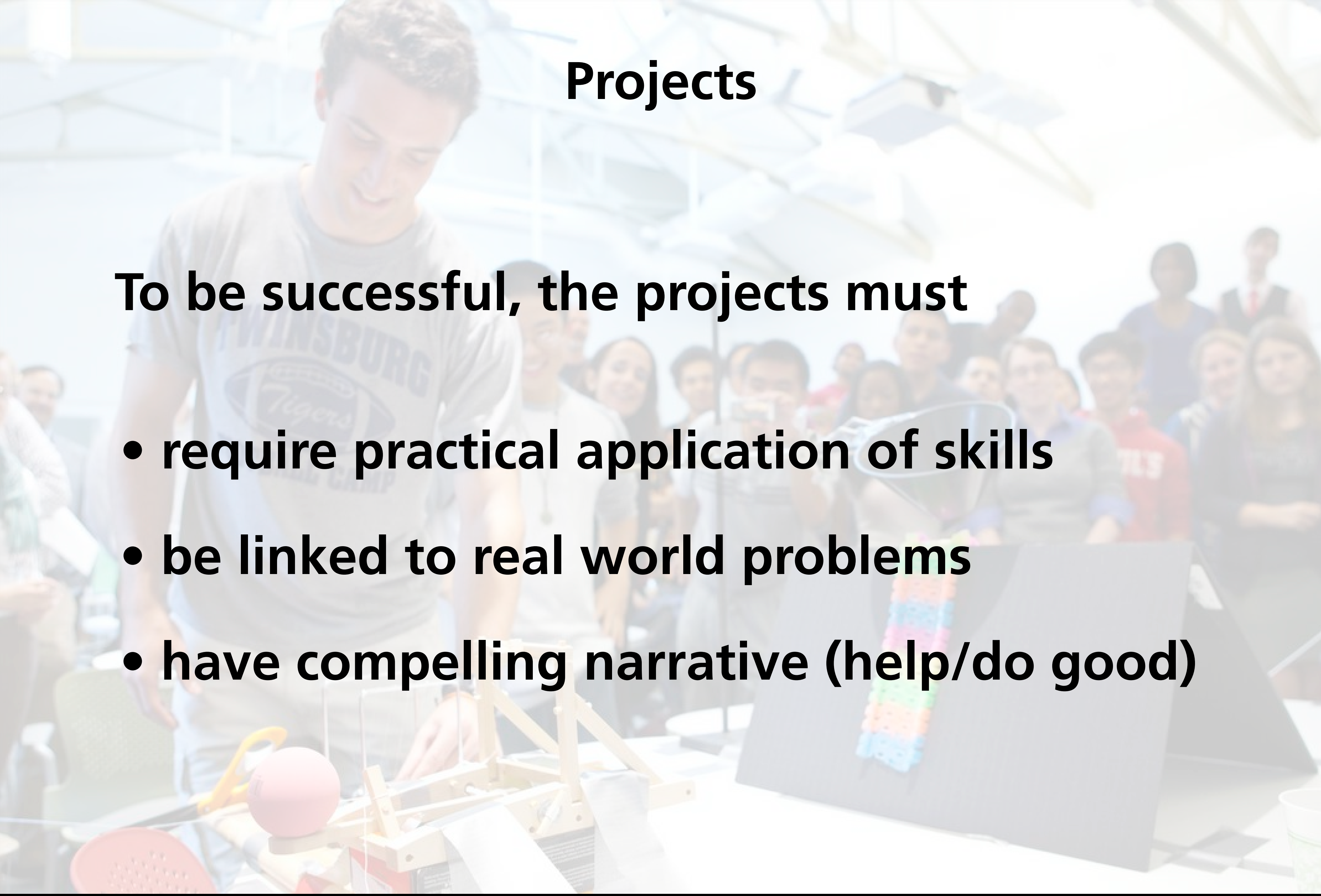
1 information transfer

2 projects



- **1 project/month (6 over 2 semesters)**
- **new team formation for each project**

❶ information transfer ❷ projects



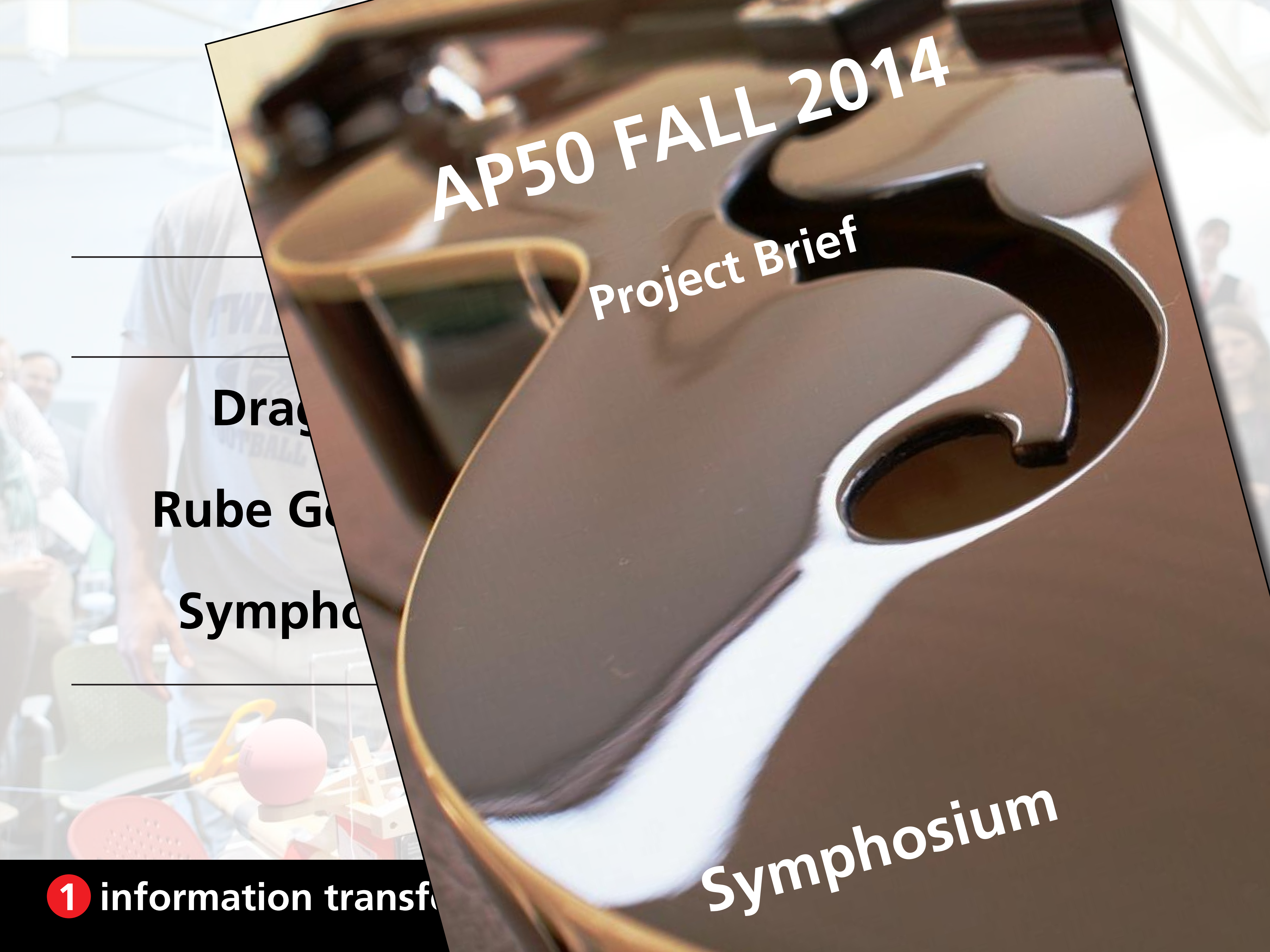
Projects

To be successful, the projects must

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

Projects

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


AP50 FALL 2014
Project Brief
Symphosium
Drag
Rube G
Sympho
1 information transf

1 information transfer   2 projects

Projects

❶ information transfer ❷ projects

Projects

Build a beautifully sounding instrument from recycled parts

Projects

Build a beautifully sounding instrument from recycled parts

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

Projects

Milestones:

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

Projects

Milestones:

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

Projects

Milestones:

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

Projects

Milestones:

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

Projects

Milestones:

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

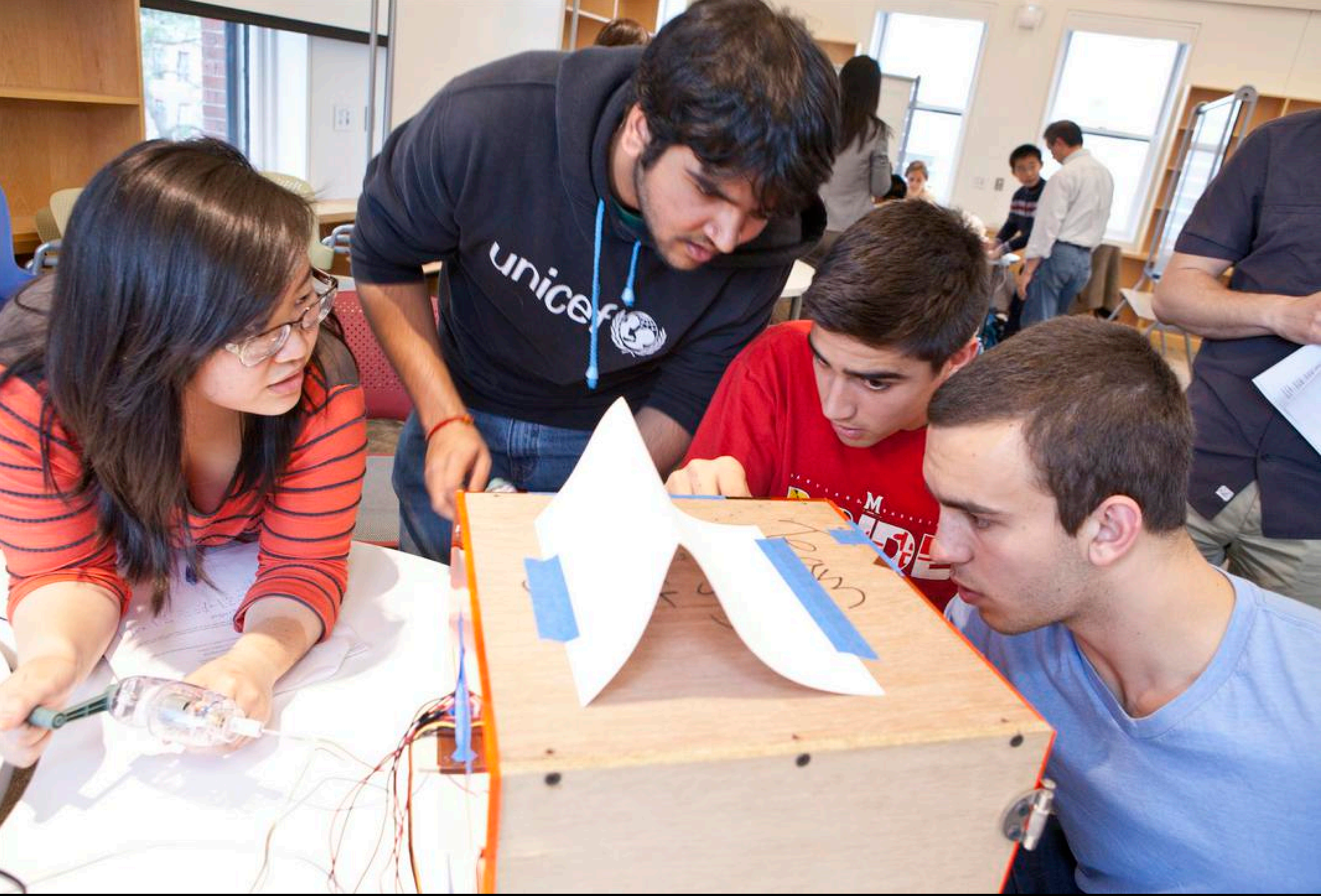
Projects

Milestones:

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

1 information transfer

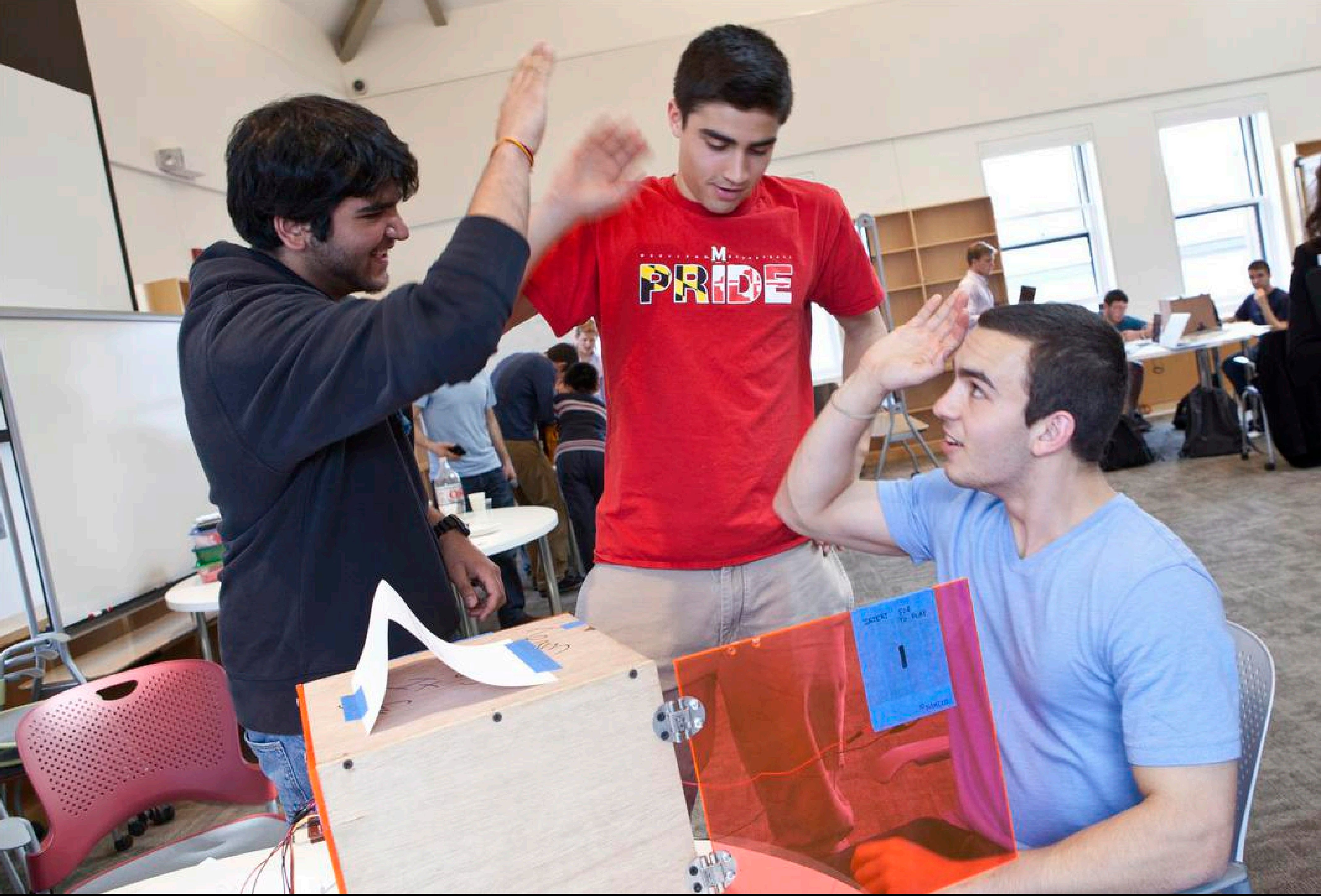
2 projects



1 information transfer **2** projects

competition instead of

social good/empathy as motivator



1 information transfer 2 projects

2 weekly 3-hour class periods

1. **information transfer**
2. **projects**
3. **in-class activities**

blend of 6 scaffolded "best practices"

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

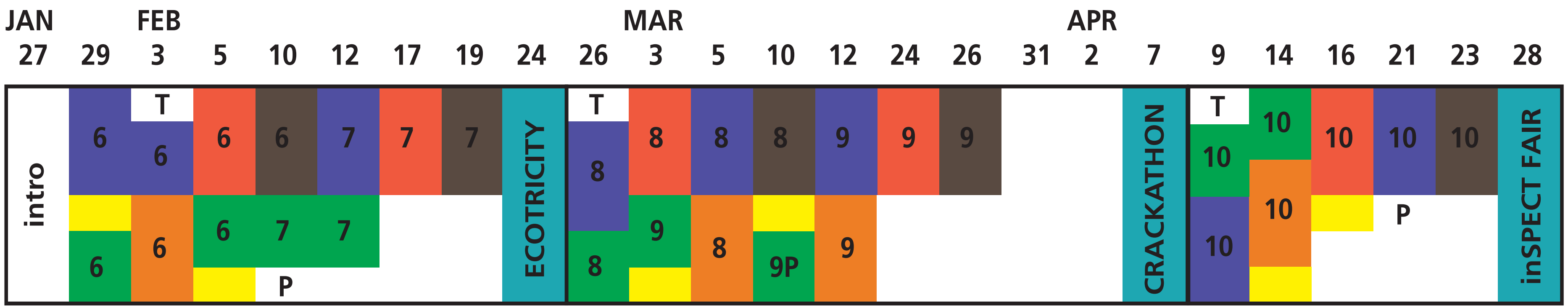
- Work problems alone BEFORE class
- Discuss with team, mark up
- Self-assess & turn in

RAA: Readiness Assurance Activity — 90 min

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

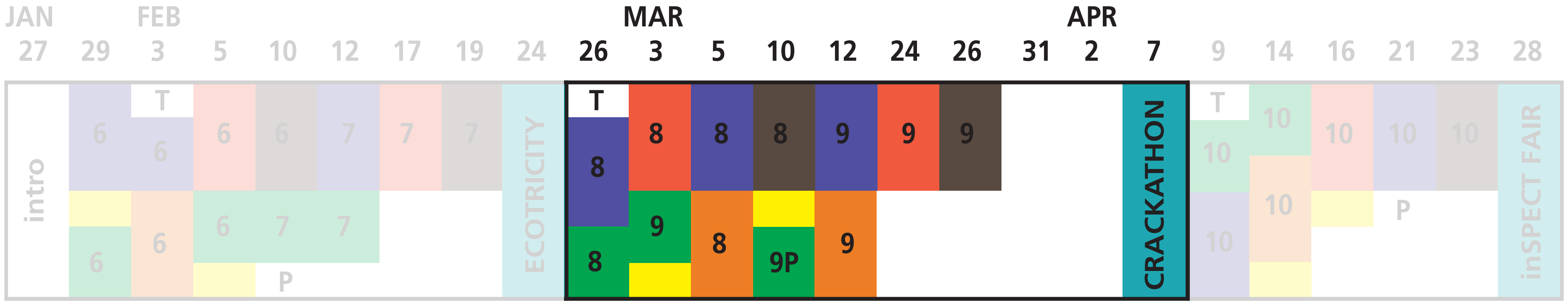
bring device

1 information transfer 2 projects 3 in-class activities



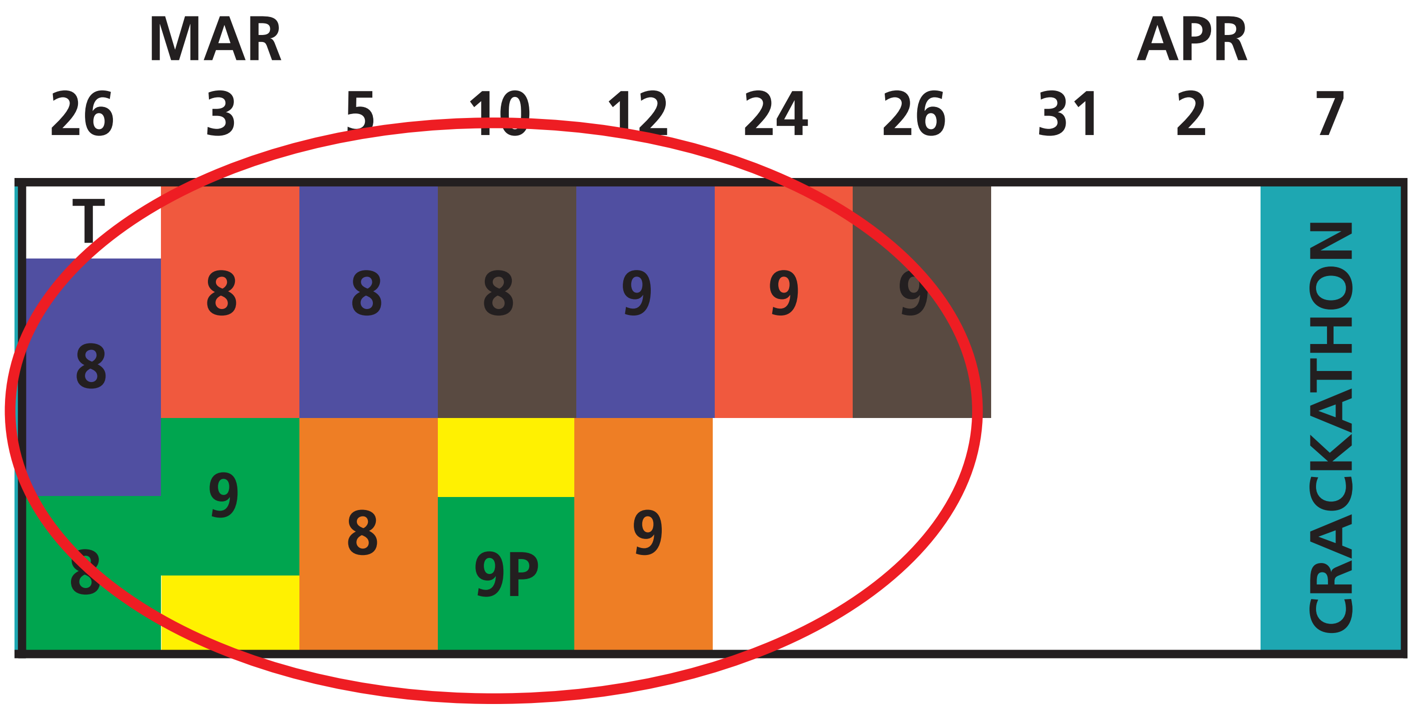
1 information transfer **2** projects **3** in-class activities

one project

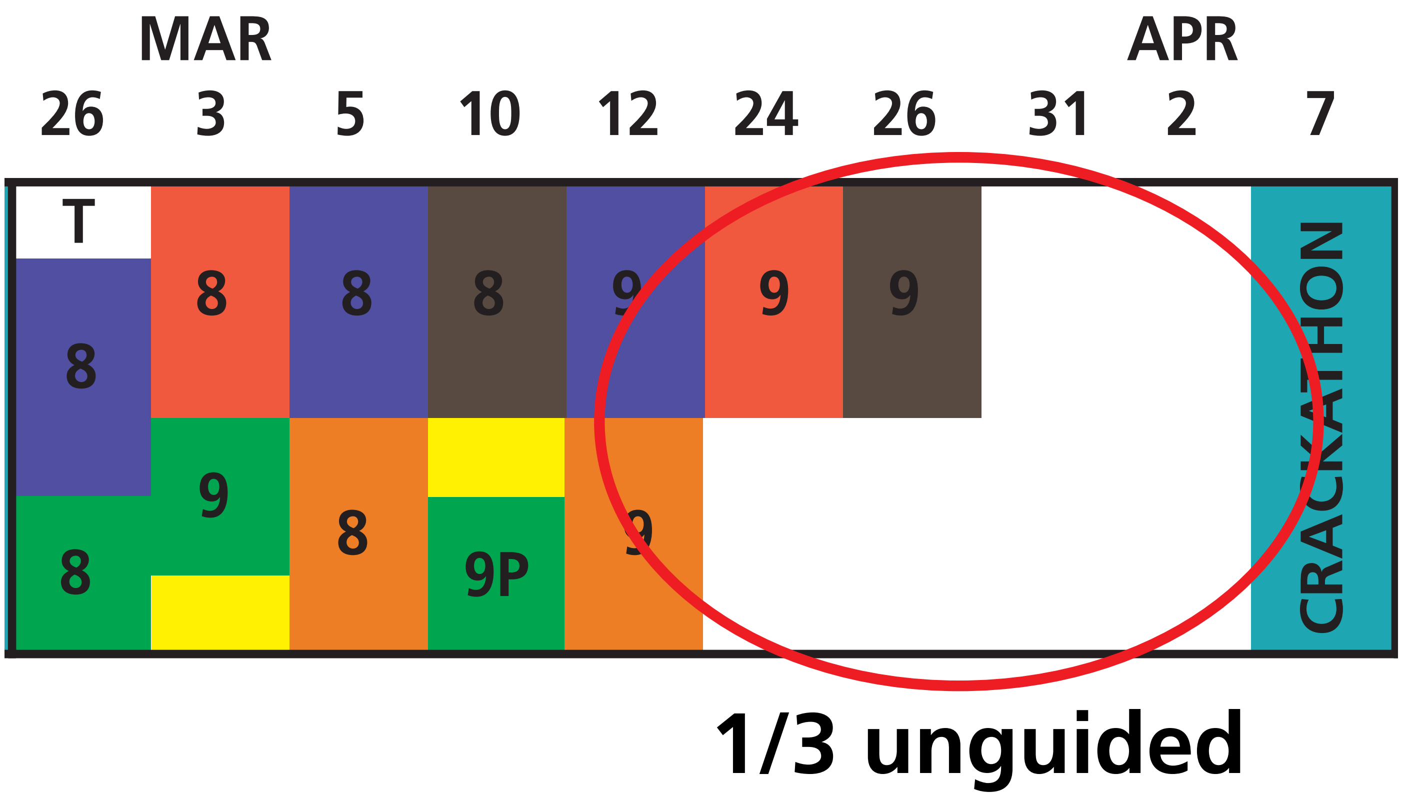


1 information transfer 2 projects 3 in-class activities

2/3 scaffolded, guided



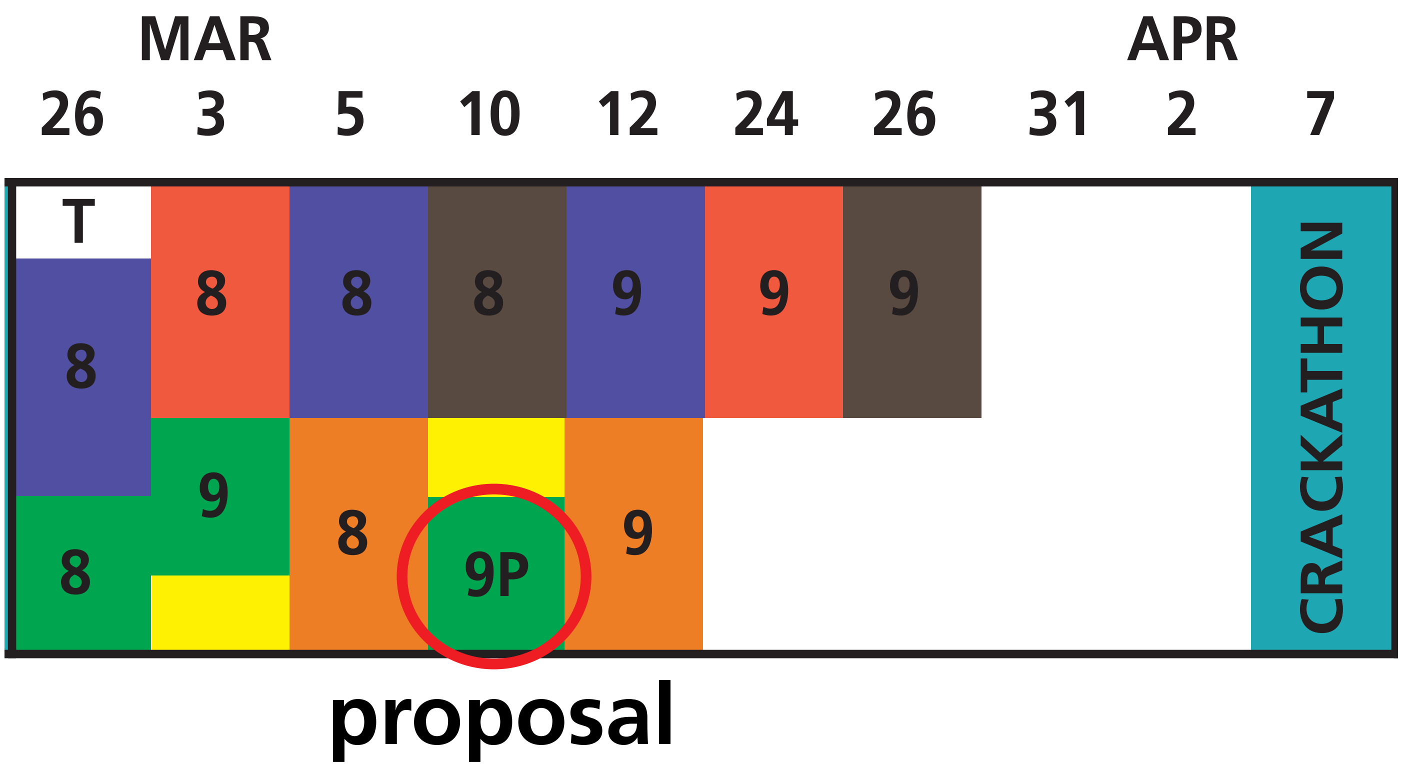
1 information transfer   2 projects   3 in-class activities



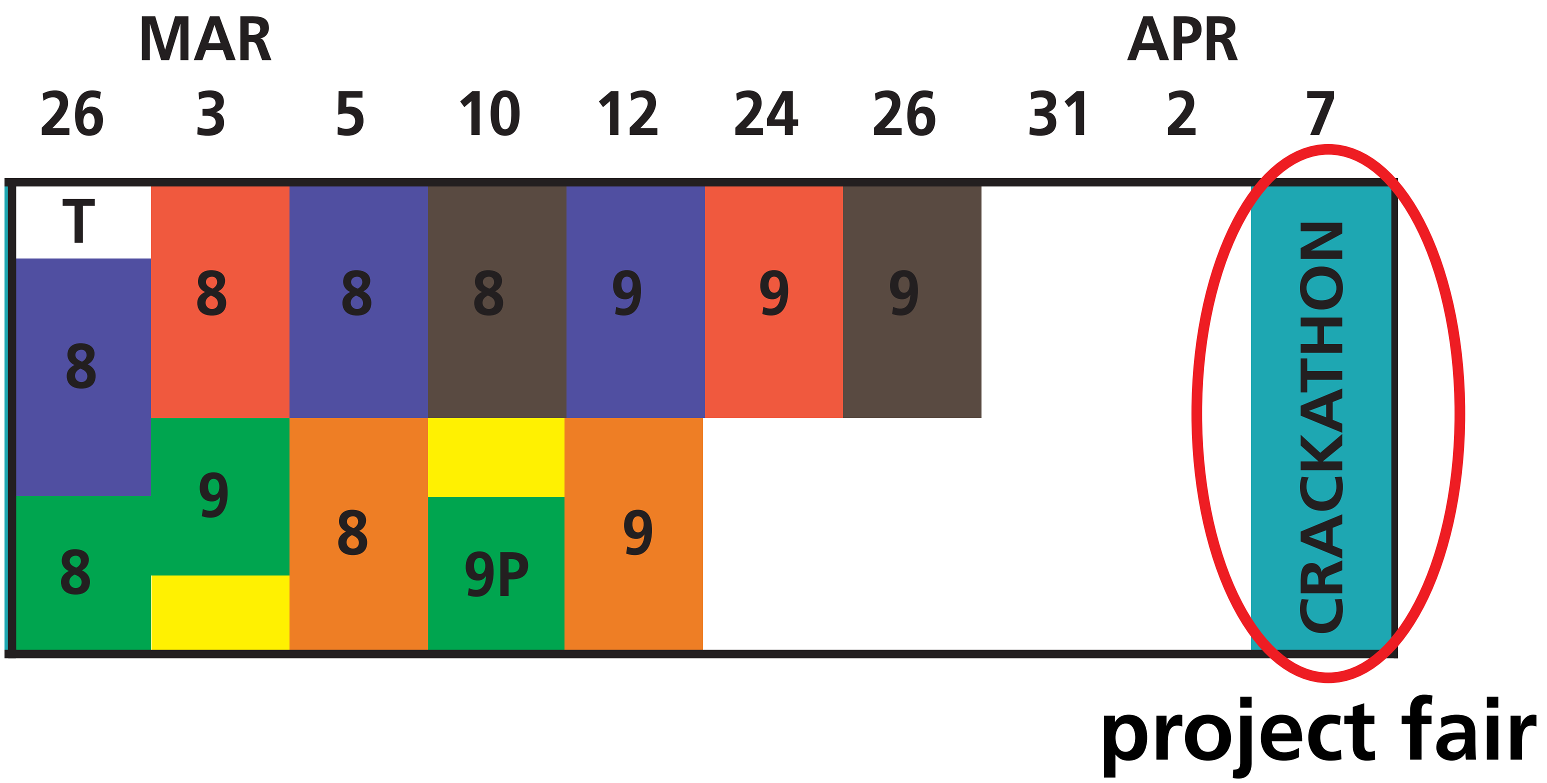
1 information transfer
2 projects
3 in-class activities

team intro

1 information transfer
2 projects
3 in-class activities



1 information transfer 2 projects 3 in-class activities



1 information transfer 2 projects 3 in-class activities

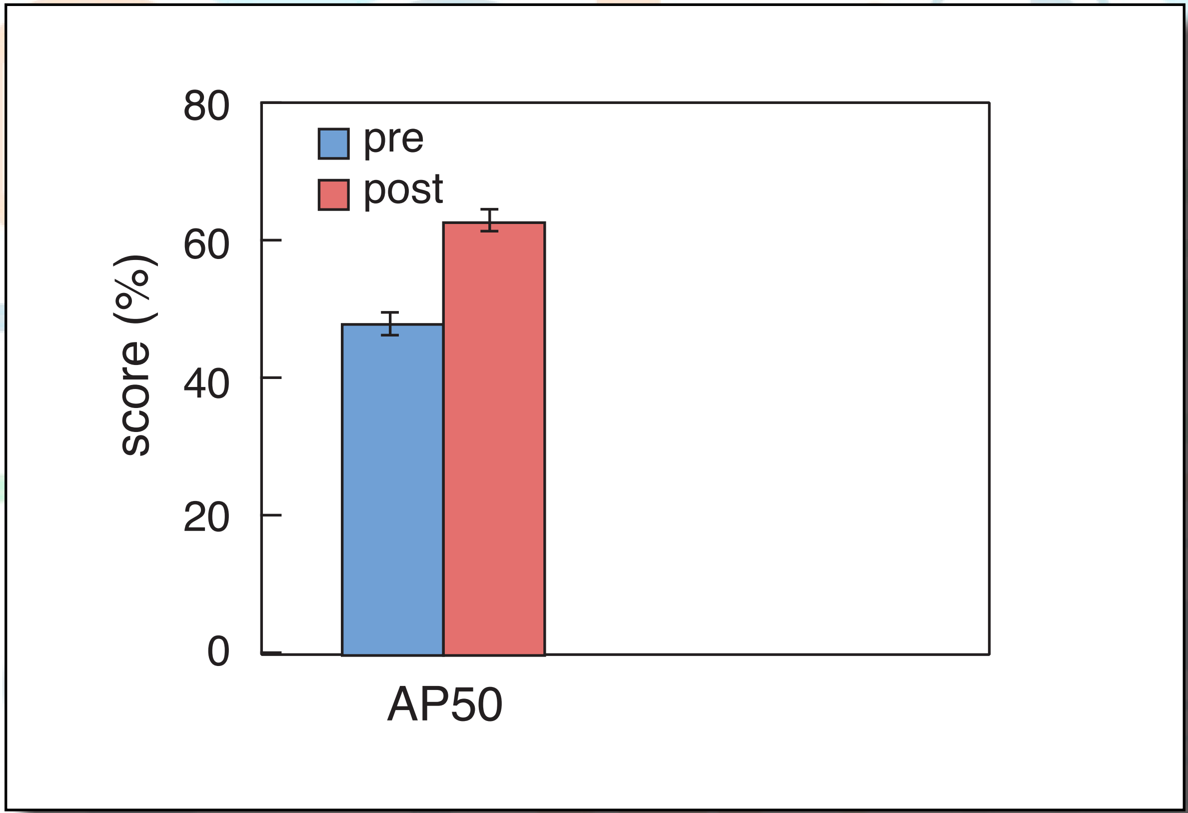
Course outcomes

- self-directed learning
- content learning goals
- teamwork
- professionalism

Content learning goals

Content learning goals

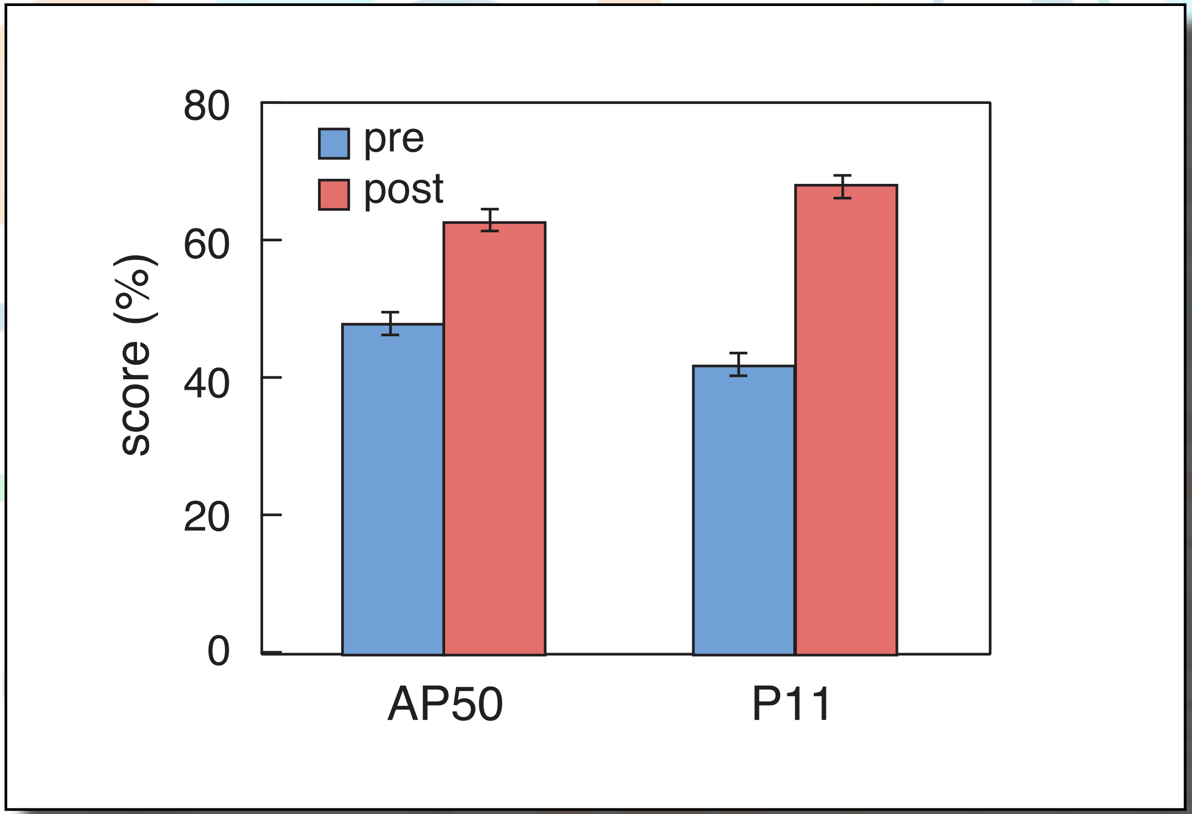
conceptual mastery



similar to lecture based course

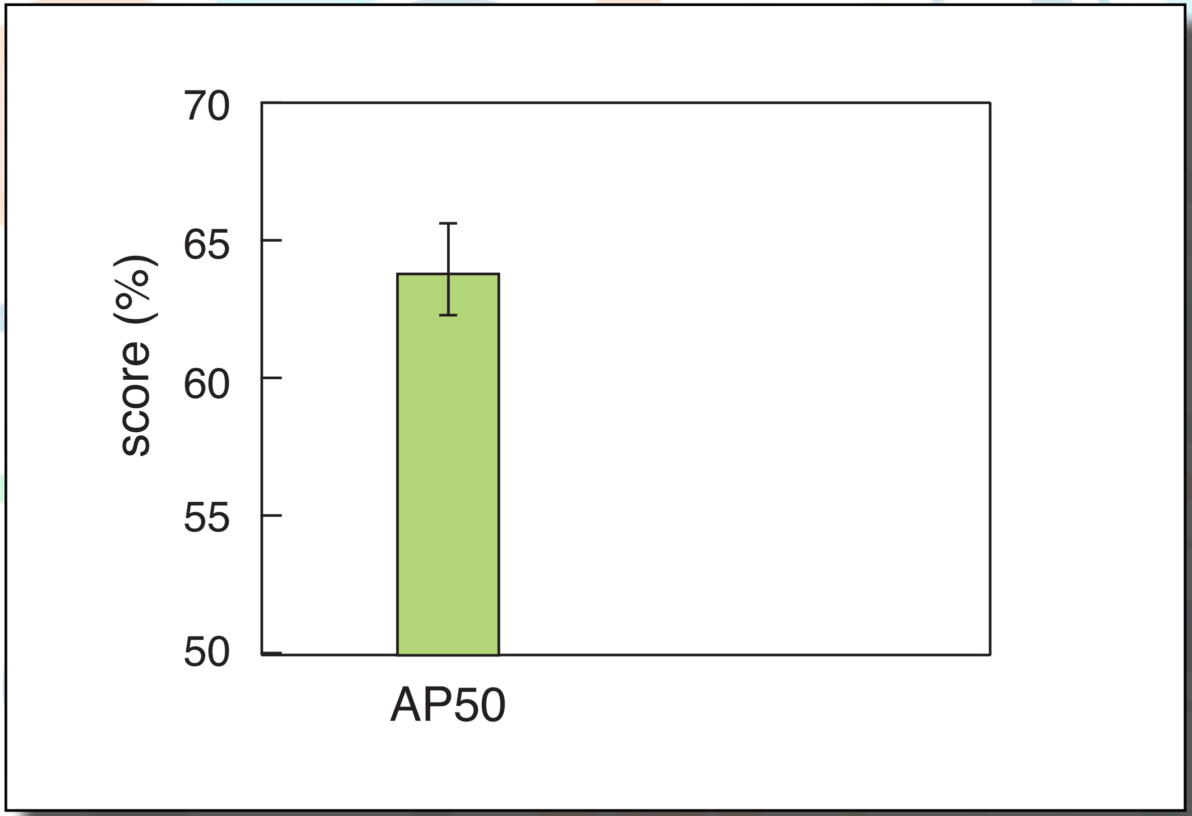
Content learning goals

conceptual mastery



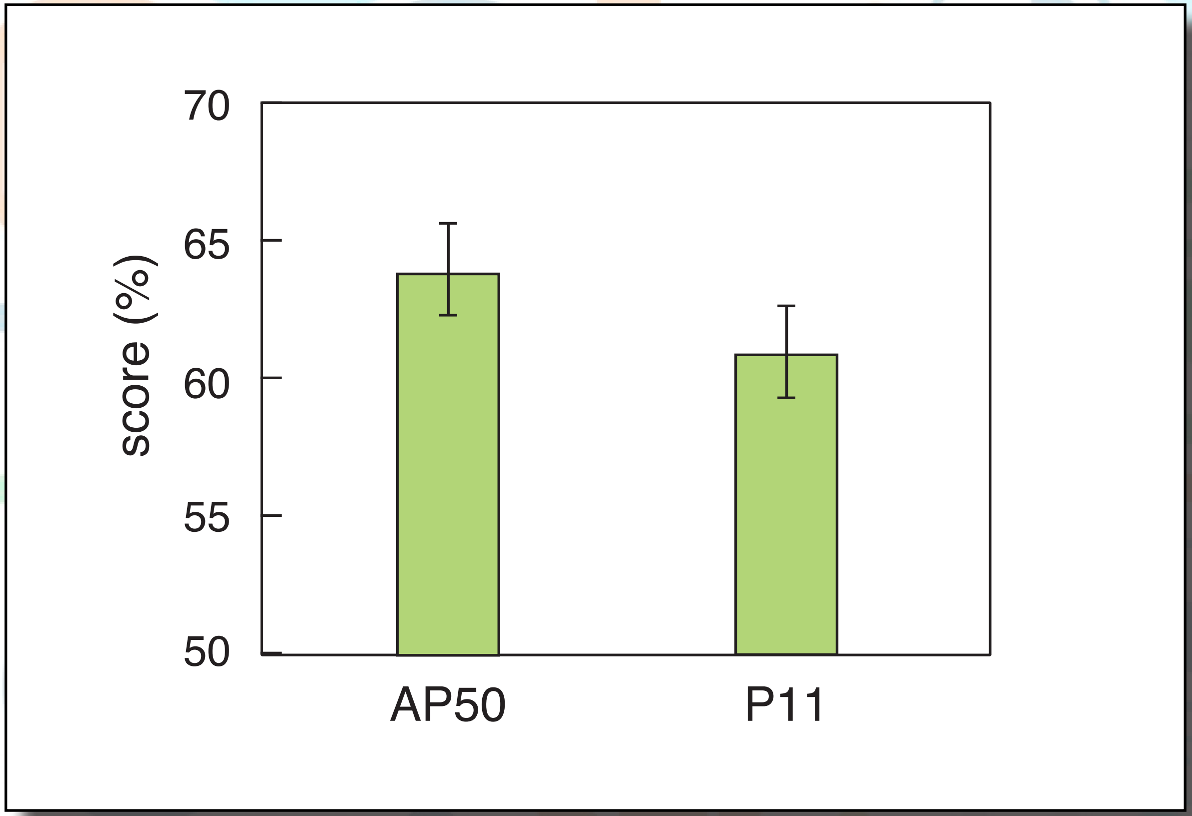
Content learning goals

exam problem performance



Content learning goals

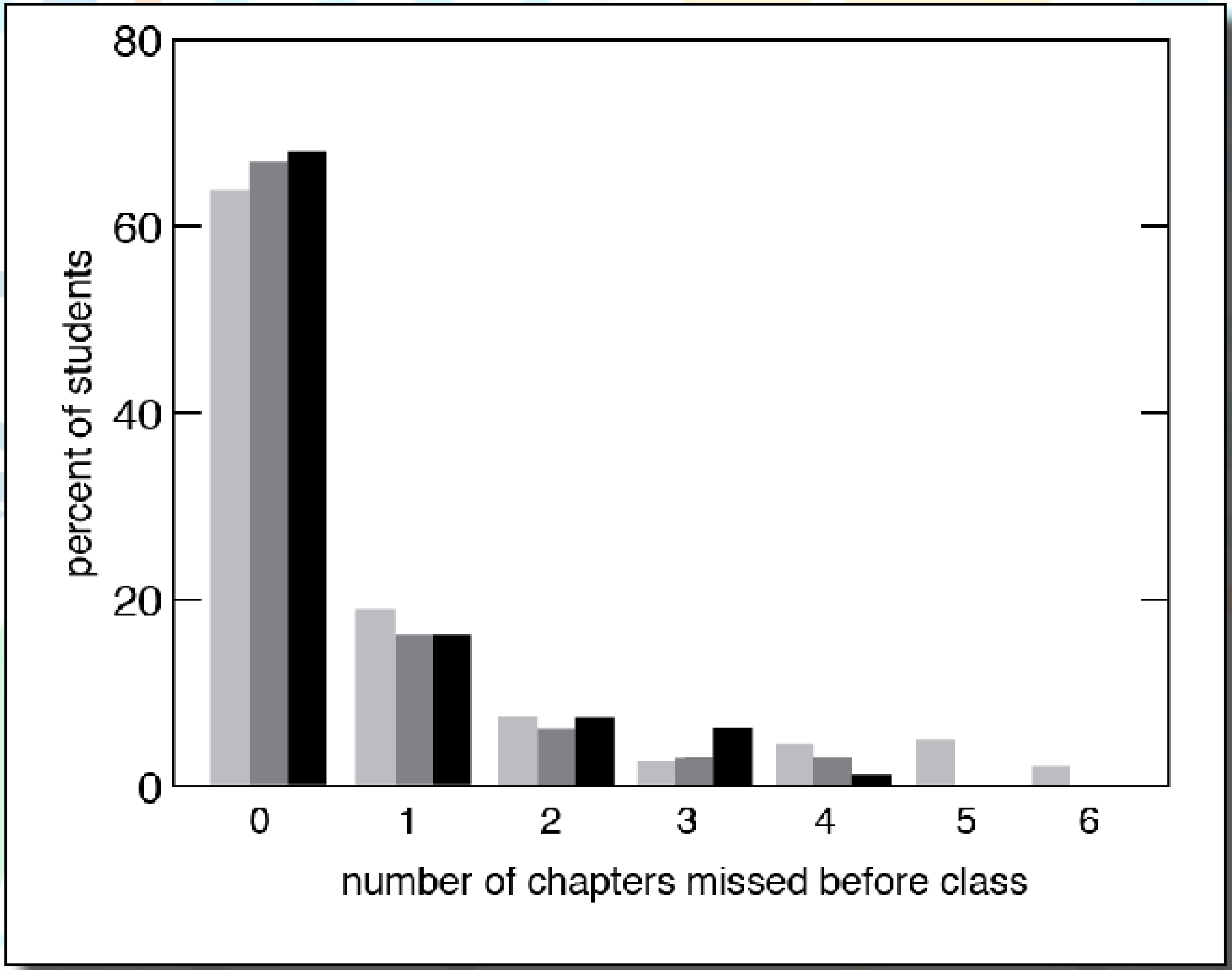
exam problem performance



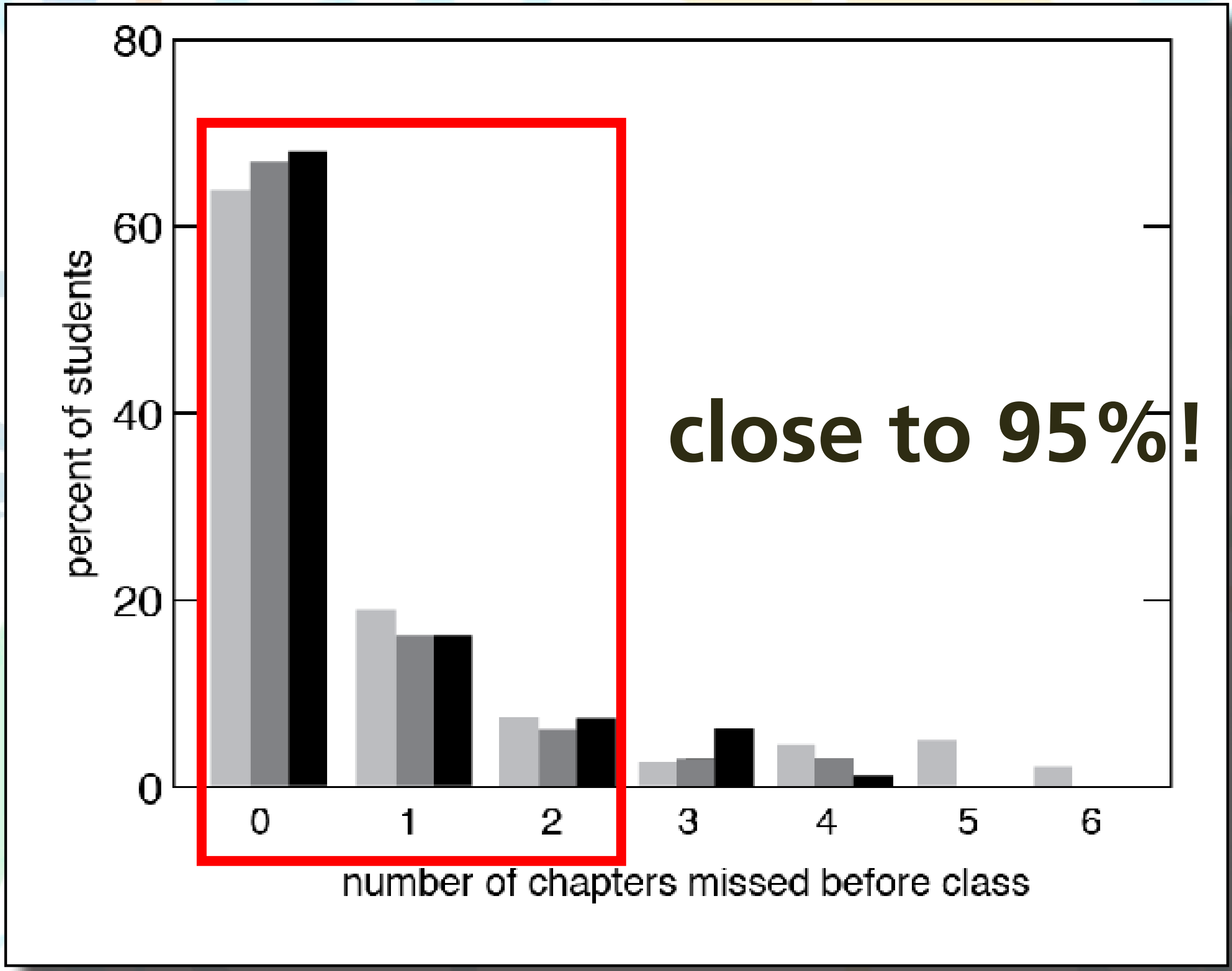
similar to lecture based course

Self directed learning

Self directed learning



Self directed learning



Self directed learning

81% spend 2–6 hrs/wk reading

Self directed learning

"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"

Self directed learning

Applied Physics 50a

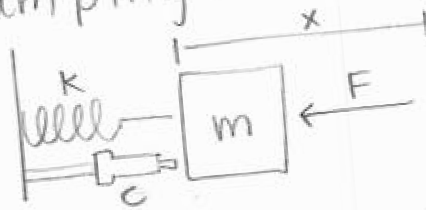
(1) Estimate damping coeff. for a shock absorber on a midsize car.

Getting started.

car moving forward

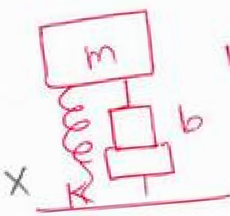
$F = m \cdot a$

Damping coeff (c)

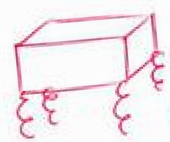


$F_s = -kx$

$F_d = -cv$



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



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

Create a plan.

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

- Approximate k of spring = 490.5 N/m

  x (distance compressed) = 0.1 m

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

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

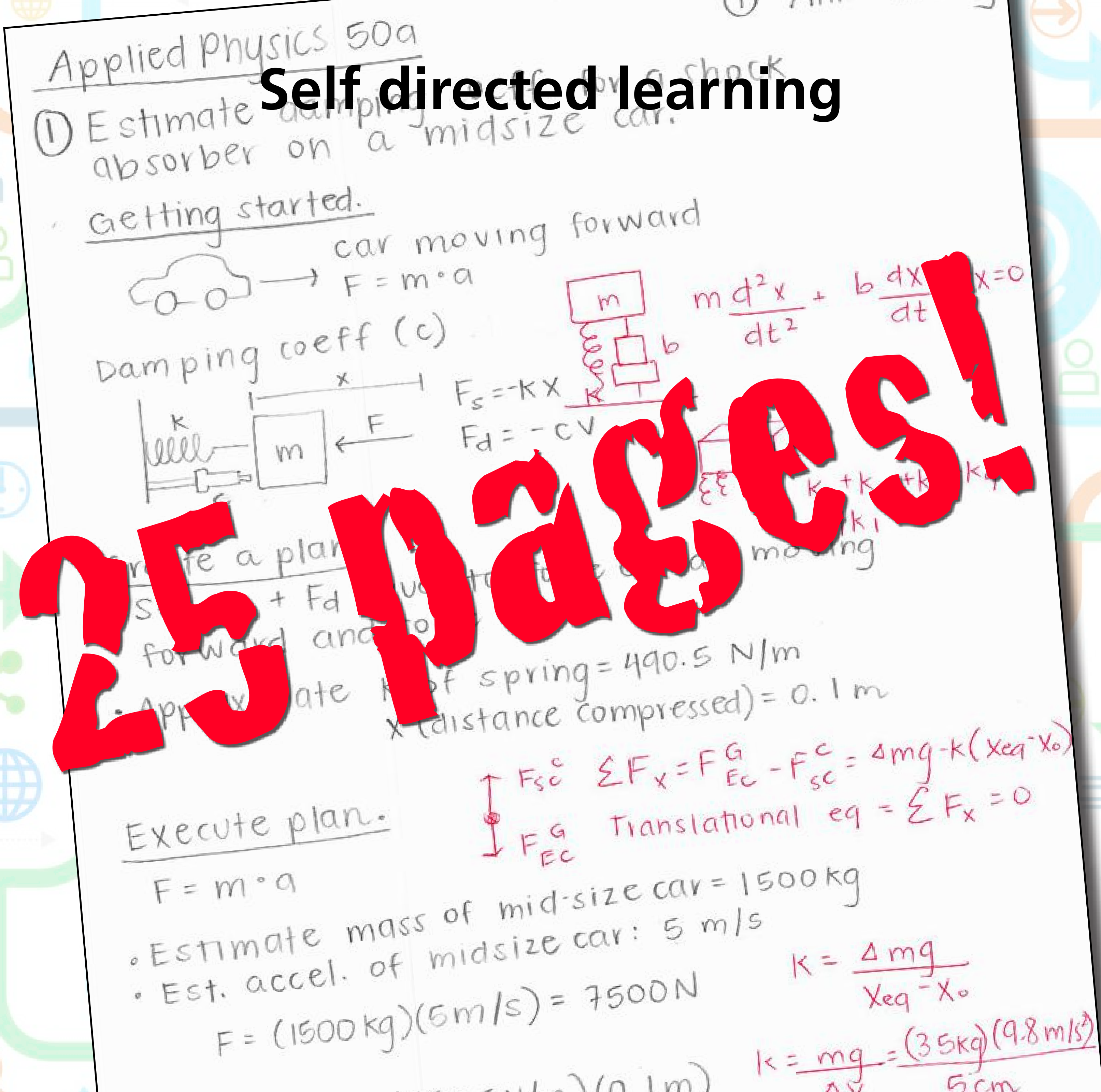
$F = (1500\,kg)(5\,m/s) = 7500\,N$

$K = \frac{\Delta mg}{x_{eq} - x_0}$

$k = \frac{mg}{\Delta x} = \frac{(35kg)(9.8\,m/s^2)}{5\,cm}$

$(0.1\,m)$

Self directed learning

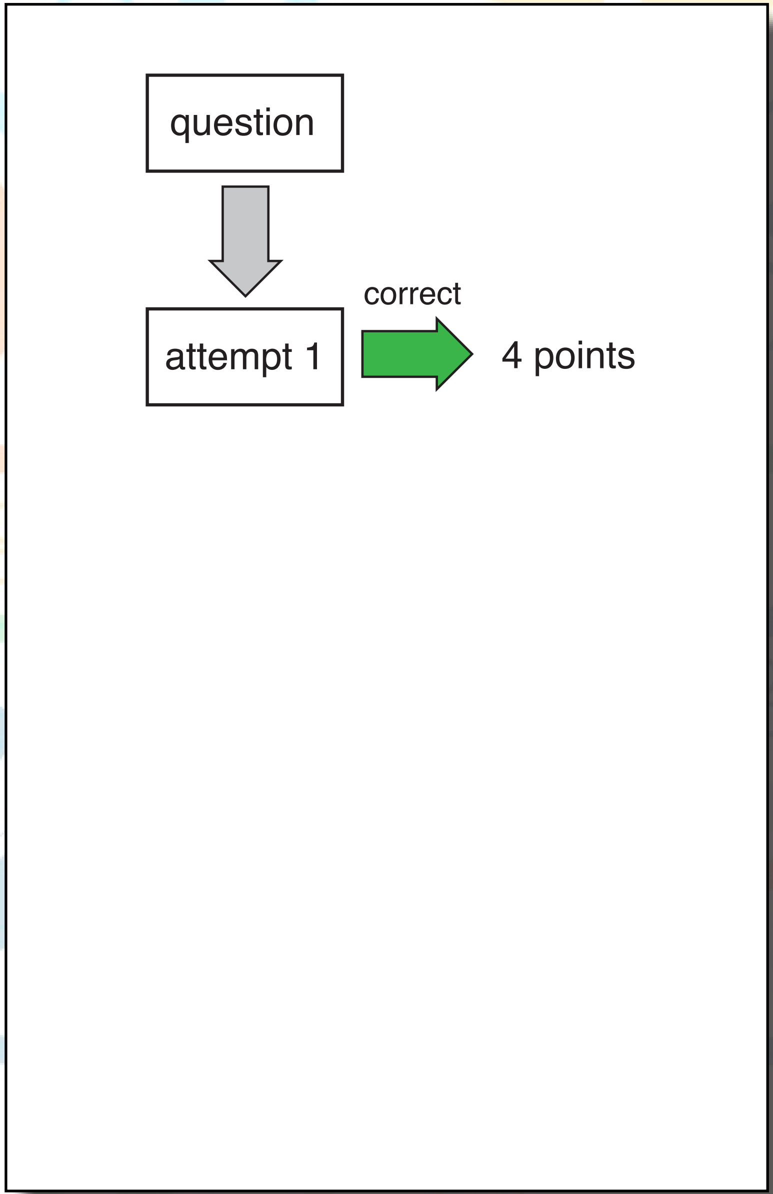


Teamwork

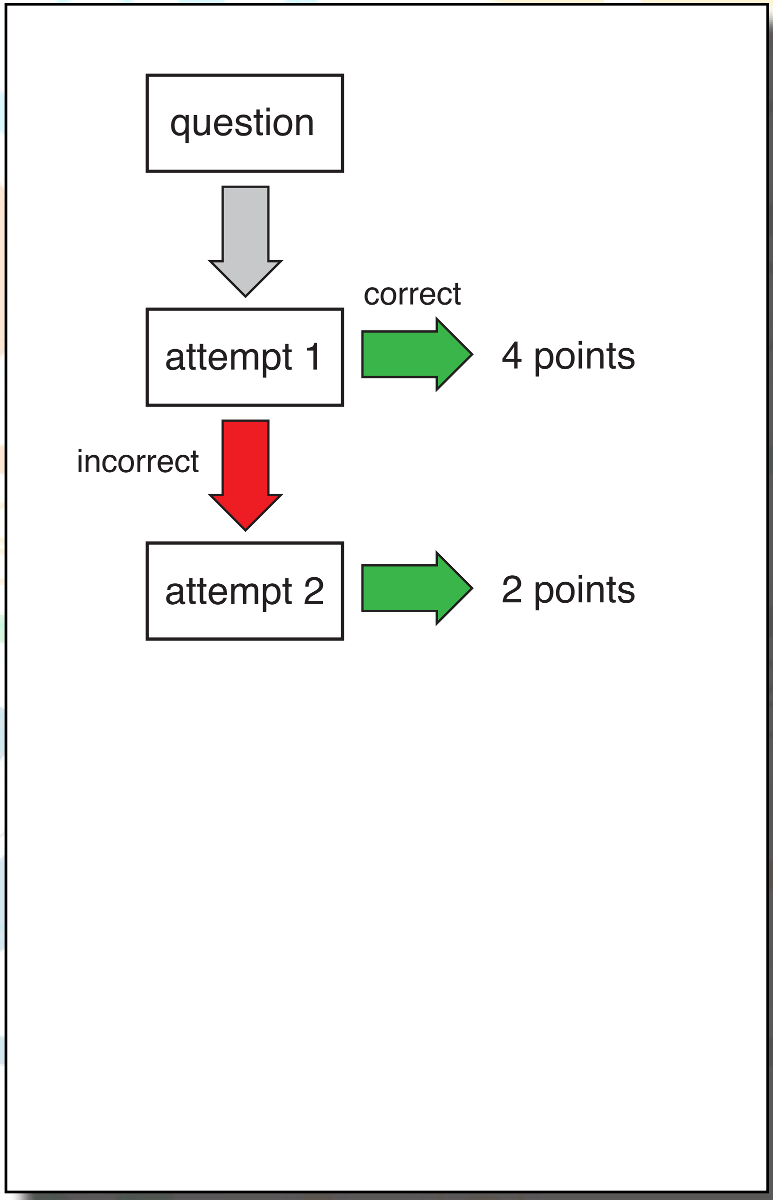
Teamwork

question

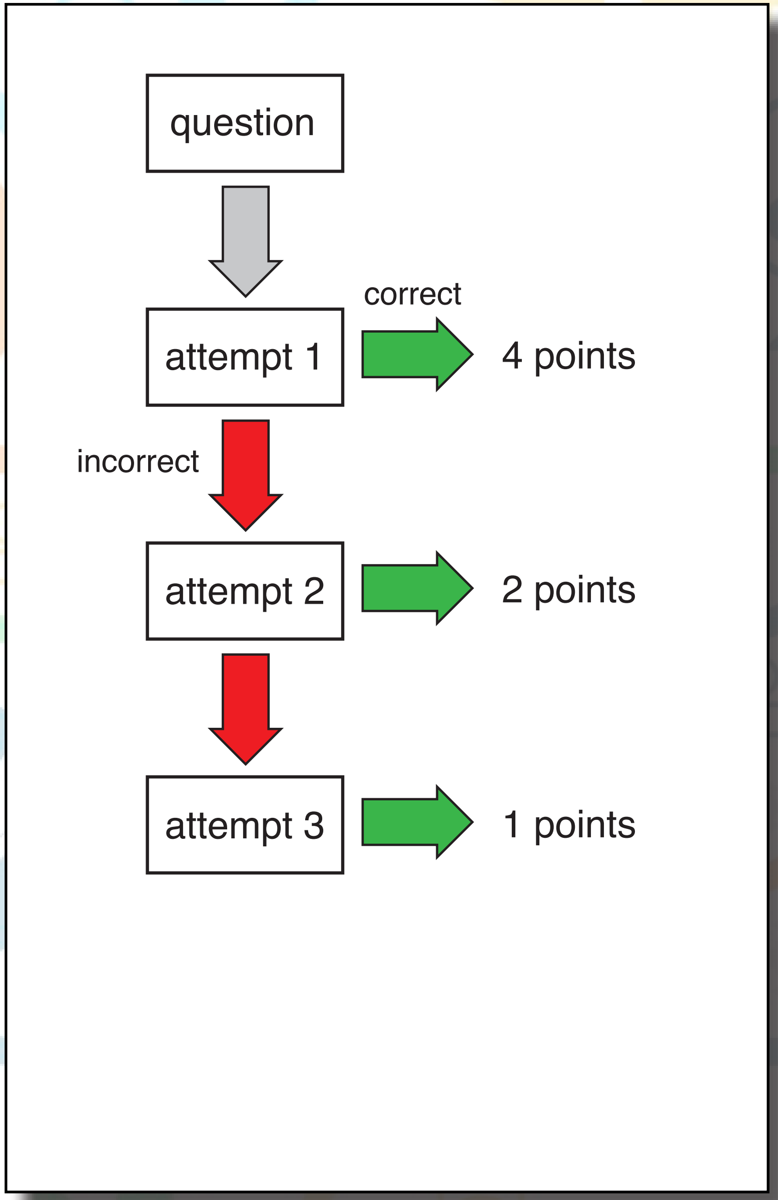
Teamwork



Teamwork

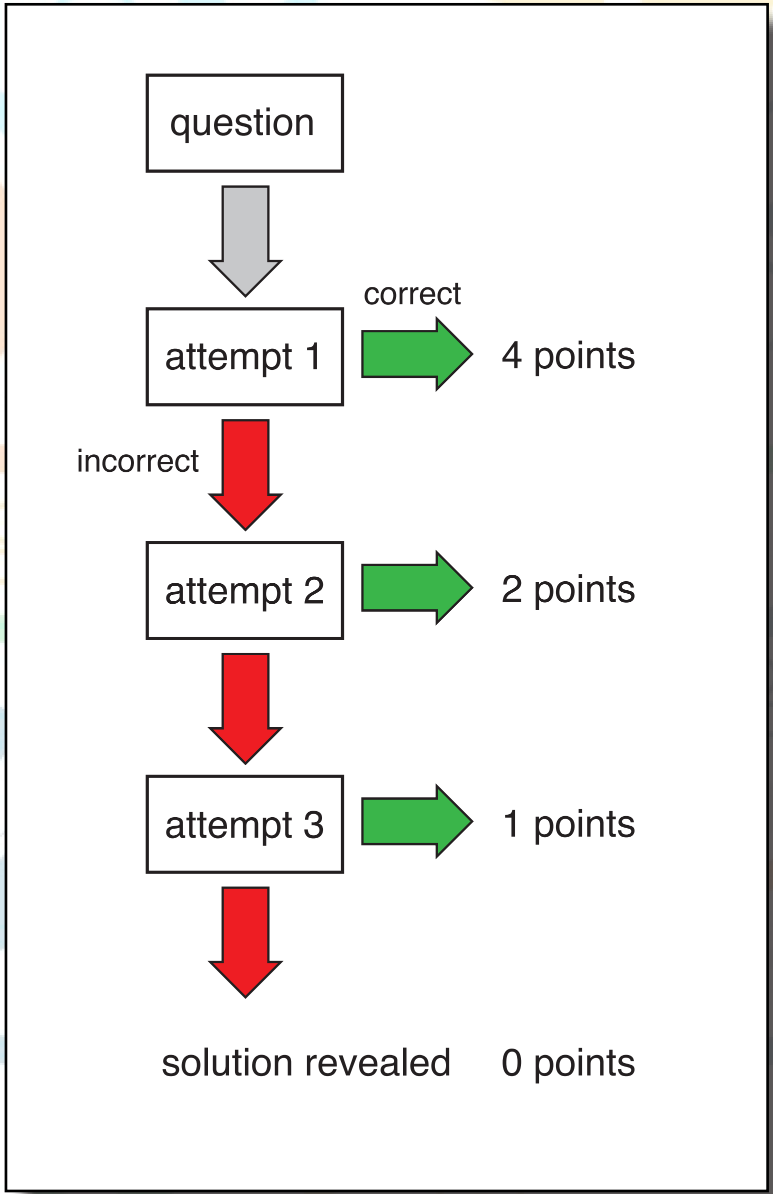

question
correct
attempt 1
4 points
incorrect
attempt 2
2 points

Teamwork

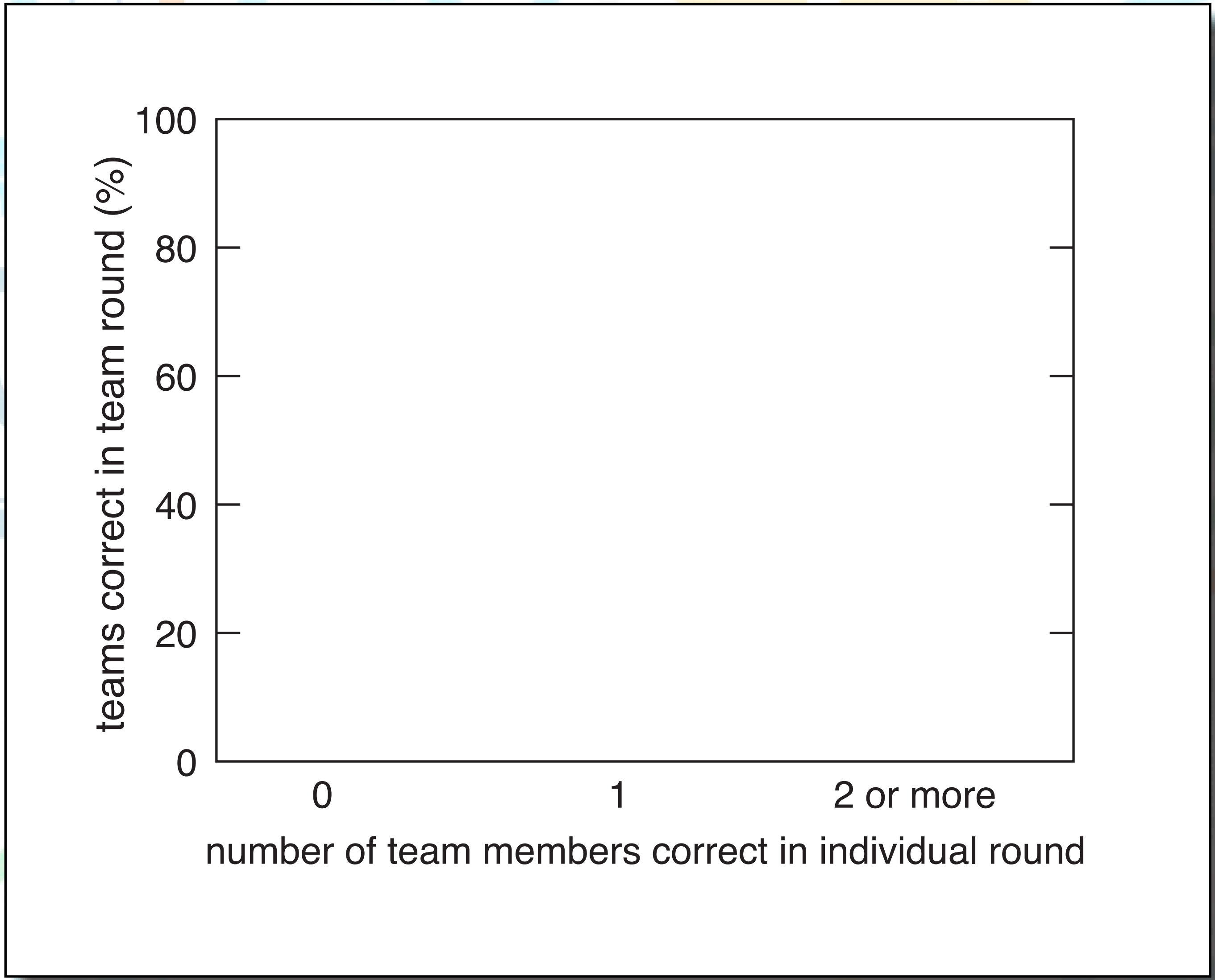


question
correct
attempt 1
4 points
incorrect
attempt 2
2 points
attempt 3
1 points

Teamwork

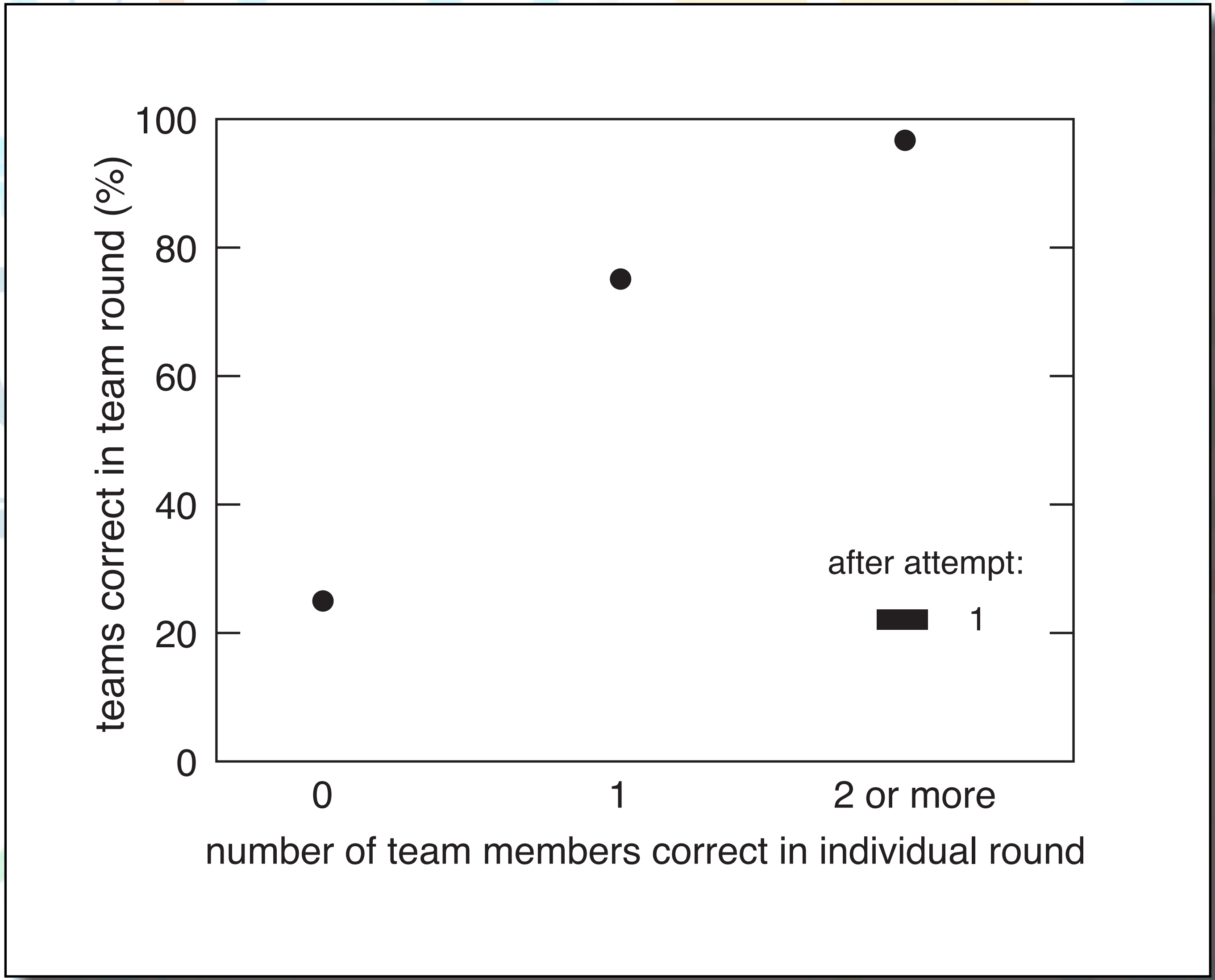

question
correct
attempt 1
4 points
incorrect
attempt 2
2 points
attempt 3
1 points
solution revealed
0 points

Teamwork



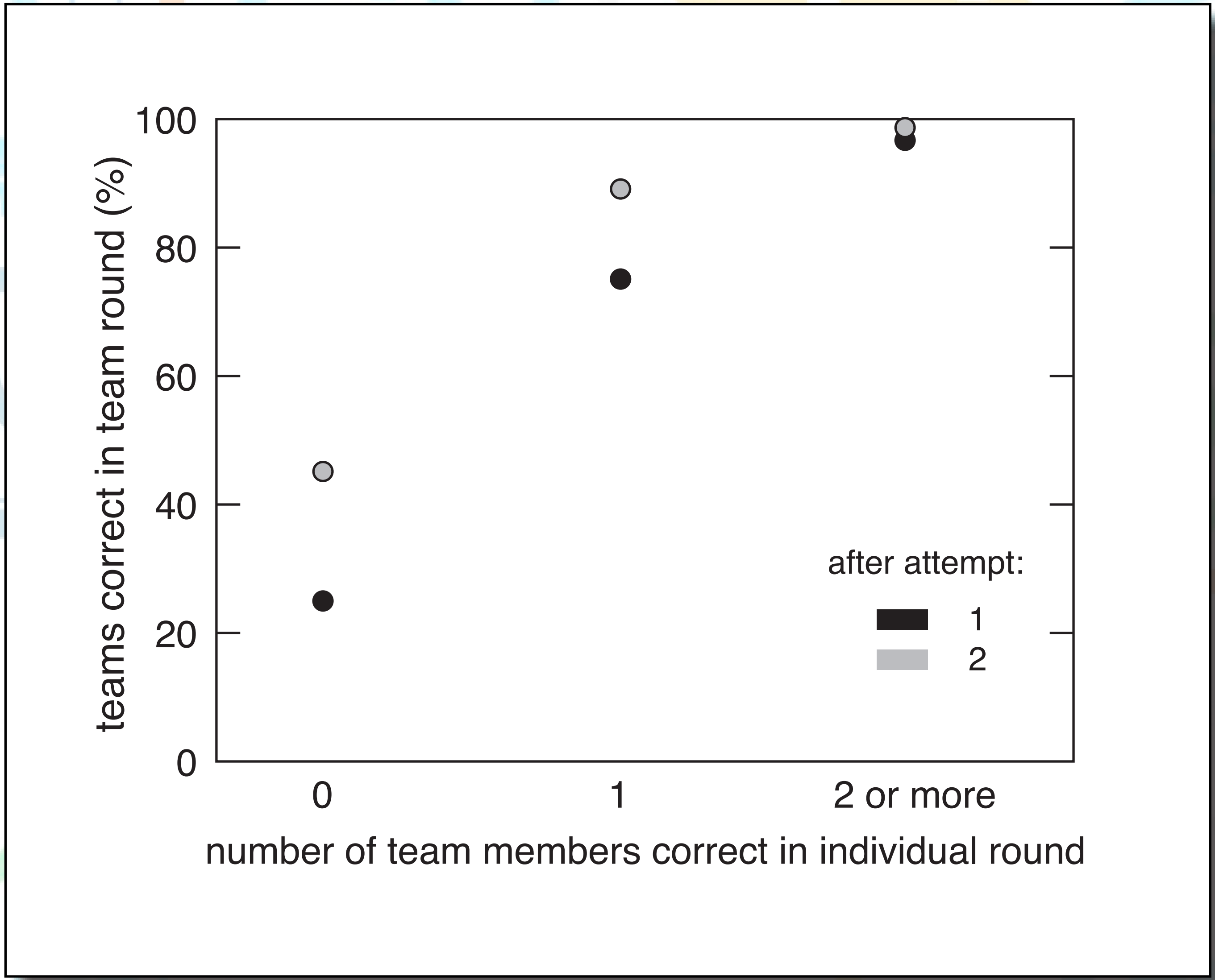
100
80
60
40
20
0
teams correct in team round (%)
0
1
2 or more
number of team members correct in individual round

Teamwork



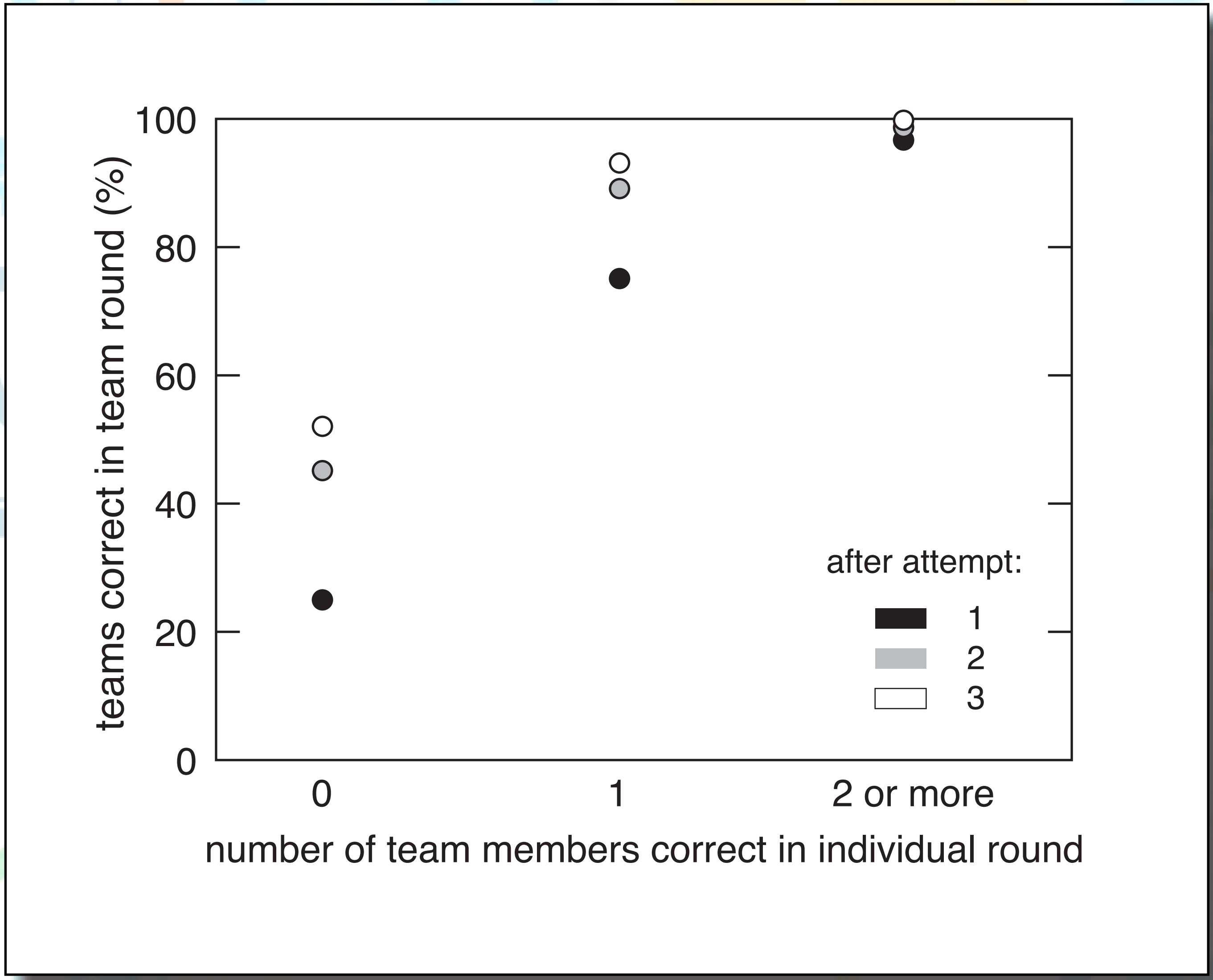
100
80
60
40
20
0
teams correct in team round (%)
after attempt:
1
0
1
2 or more
number of team members correct in individual round

Teamwork



teams correct in team round (%)
100
80
60
40
20
0
0
1
2 or more
number of team members correct in individual round
after attempt:
1
2

Teamwork



teams correct in team round (%)
100
80
60
40
20
0
0
1
2 or more
number of team members correct in individual round
after attempt:
1
2
3

Teamwork

“We were all very committed to pulling our own weight, so when someone knew they hadn’t done as much work on one part, they volunteered to take on more the next time”

Teamwork

“I think the fact that we all had experience working in groups like these was very helpful especially since we had less time to form team identity given the shorter time frame of this project. We all recognized each others’ strengths and weaknesses without needing to spell them out, and I think we capitalized on those effectively throughout the project.”

Professionalism

Professionalism

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

Ownership

Ownership

Course evaluation: 3.9–4.2/5

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

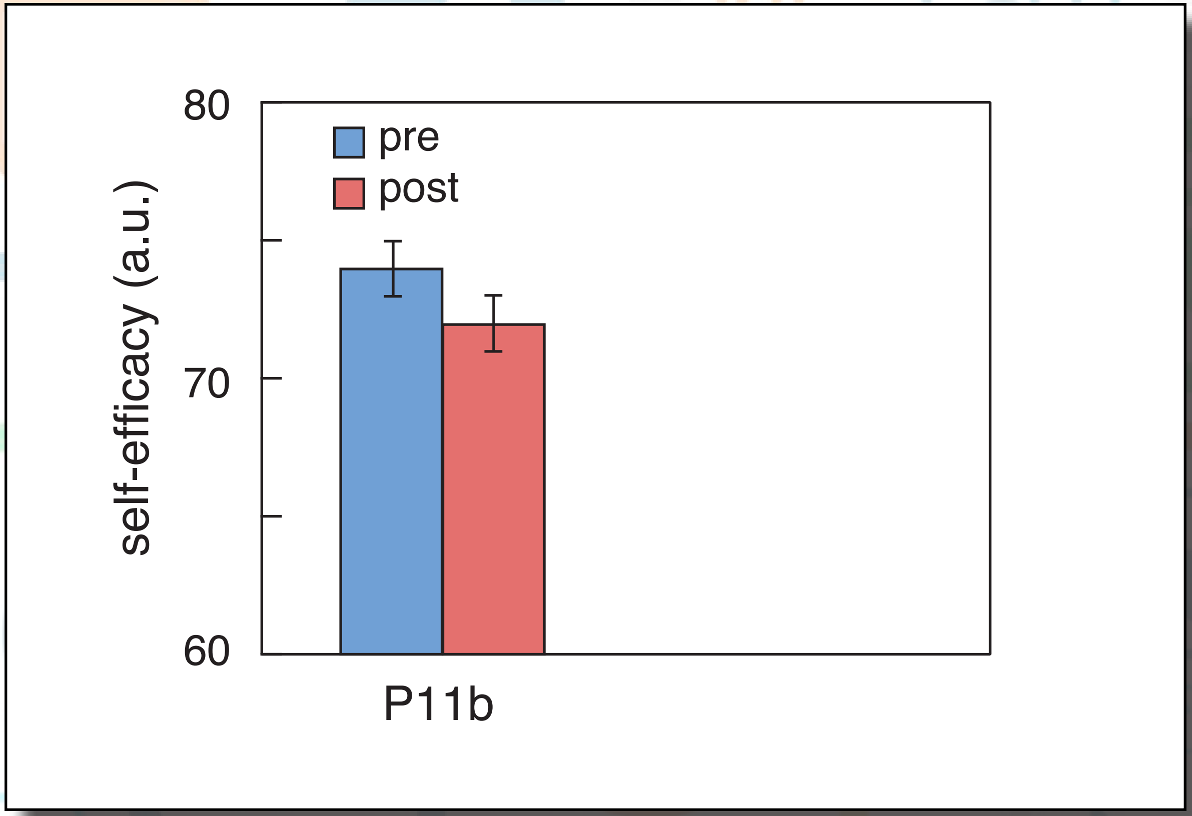
3 hours and they don't *leave*!

Ownership

self-efficacy

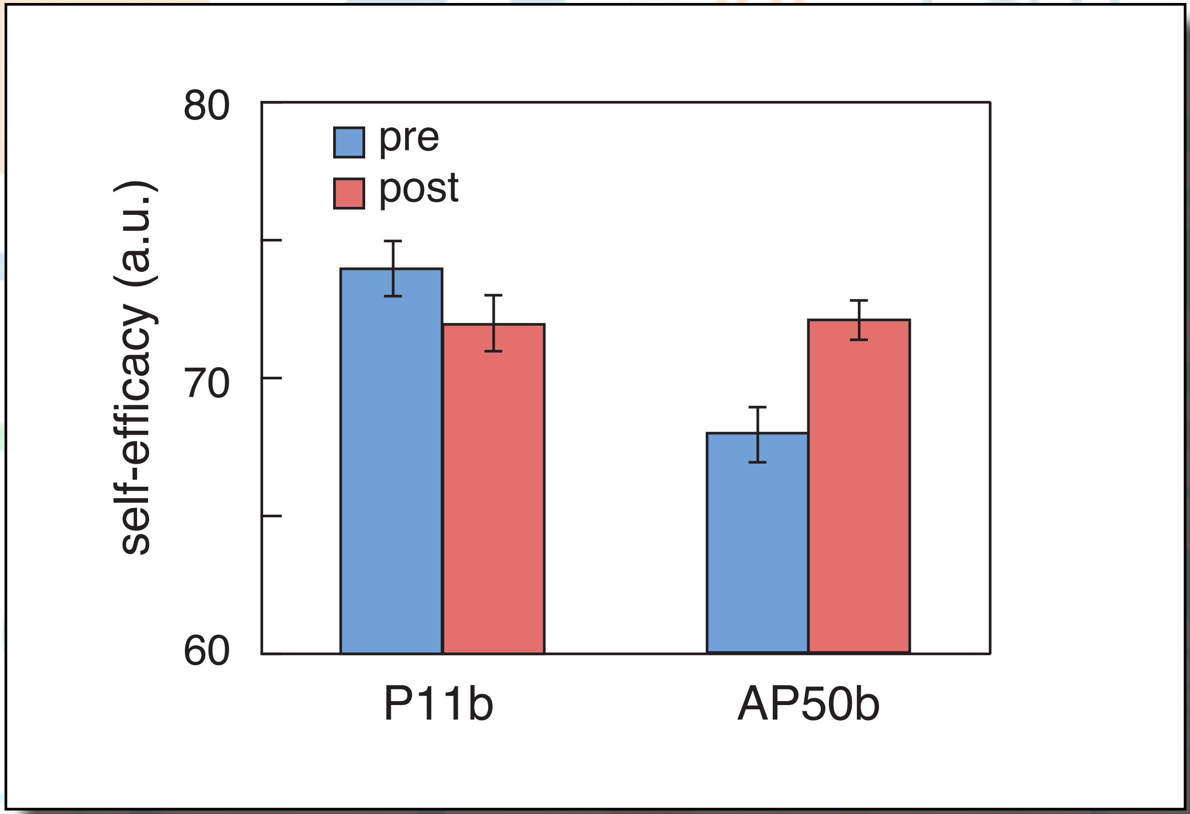
Ownership

self-efficacy



Ownership

self-efficacy




Can create ownership of learning physics!


fun!
Can create ownership of learning physics!

"you come out with so much knowledge

and experience and fun"

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