Flat space, deep learning

University of Washington
Seattle, WA, 12 May 2014

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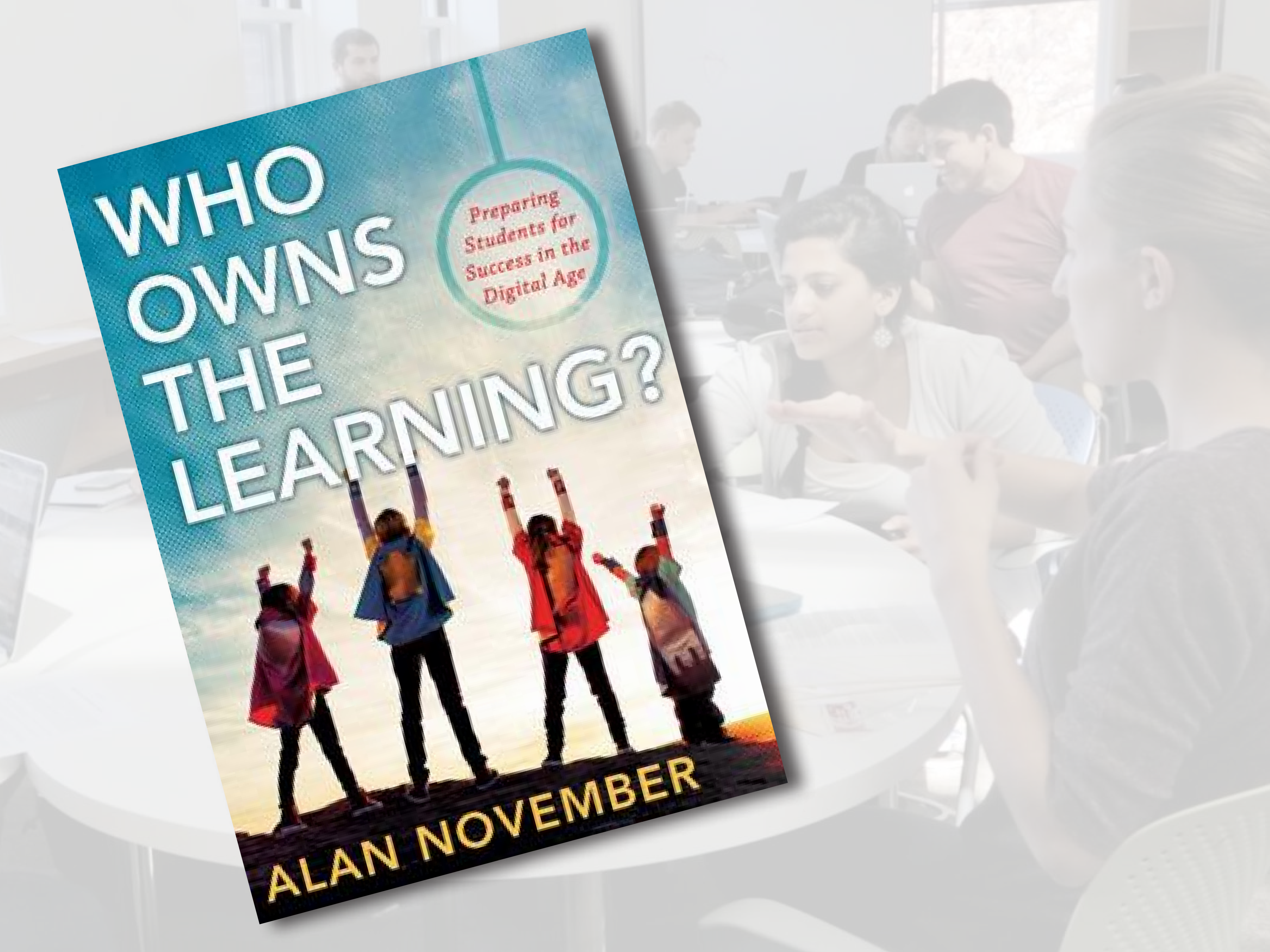
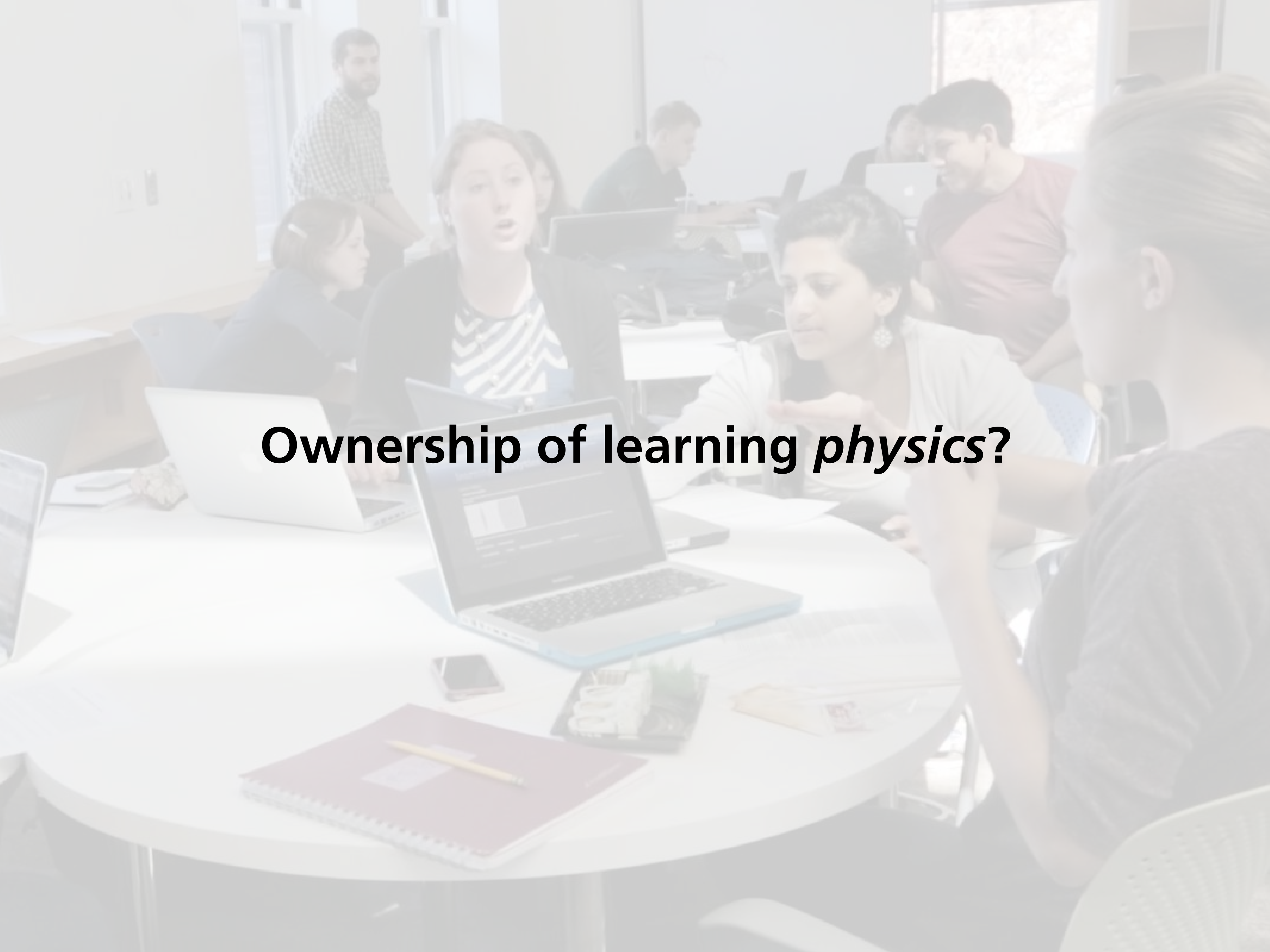
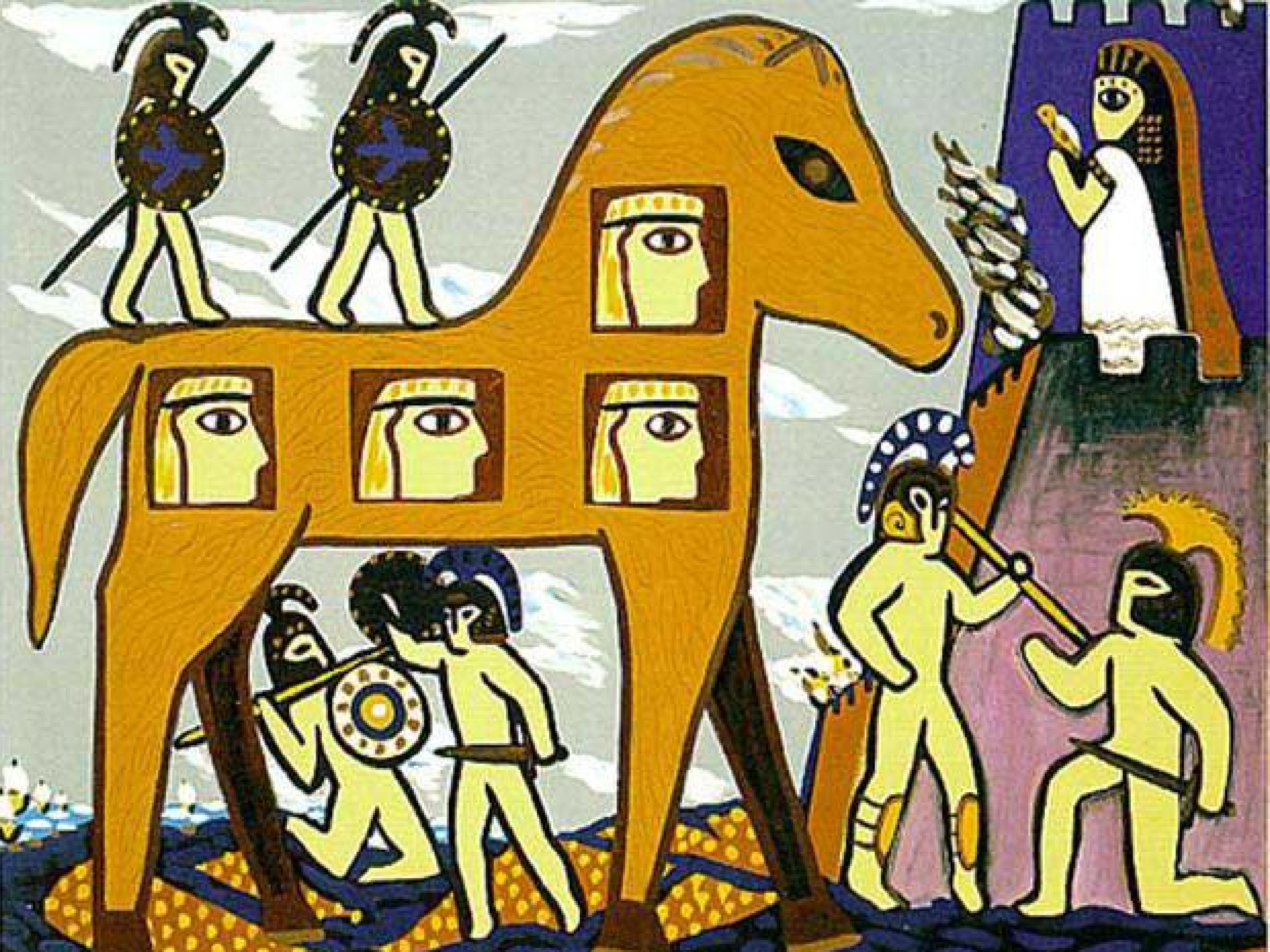

WHO OWNS THE LEARNING?
Preparing Students for Success in the Digital Age
ALAN NOVEMBER



Ownership of learning *physics*?

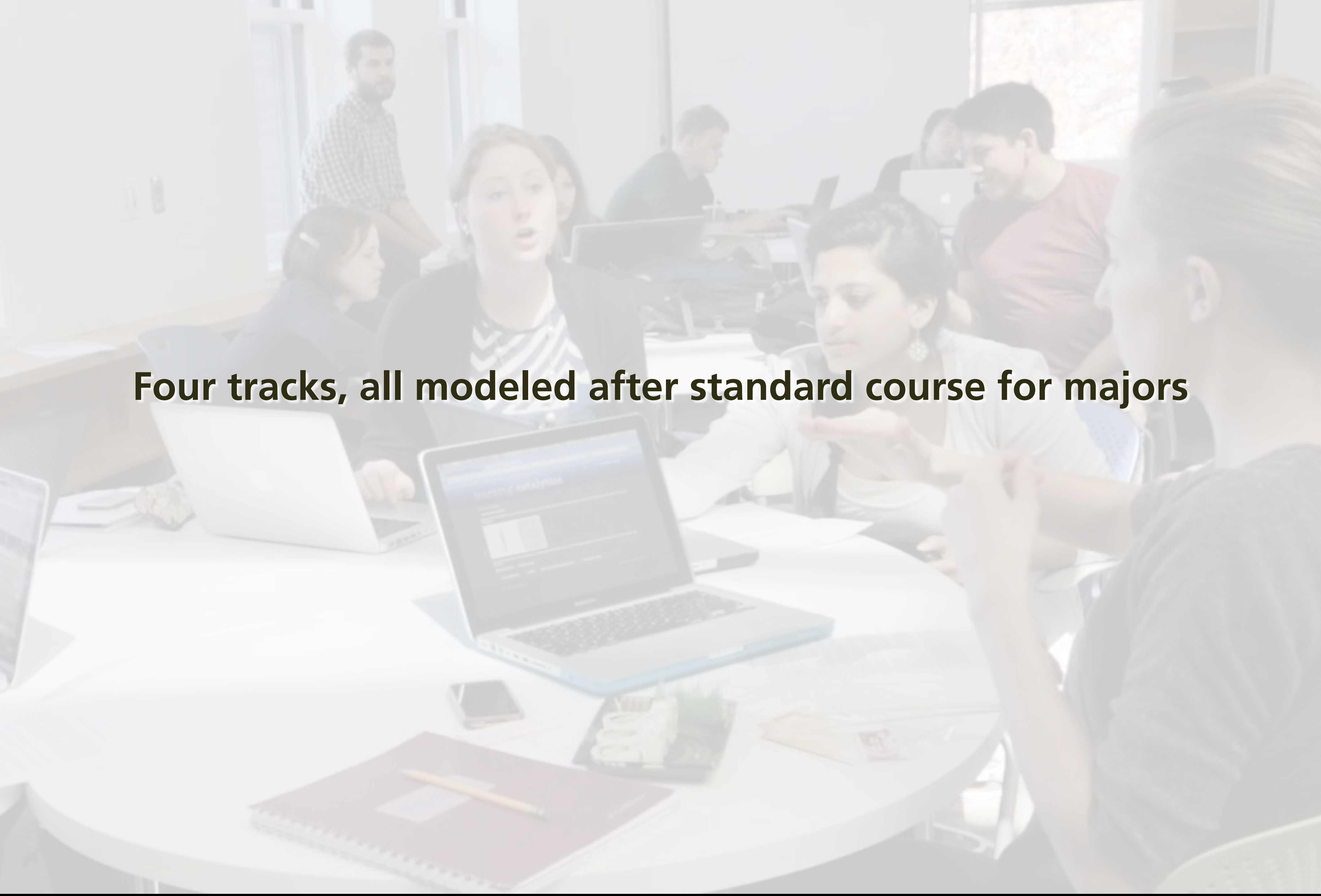


team & project-based approach

1 design

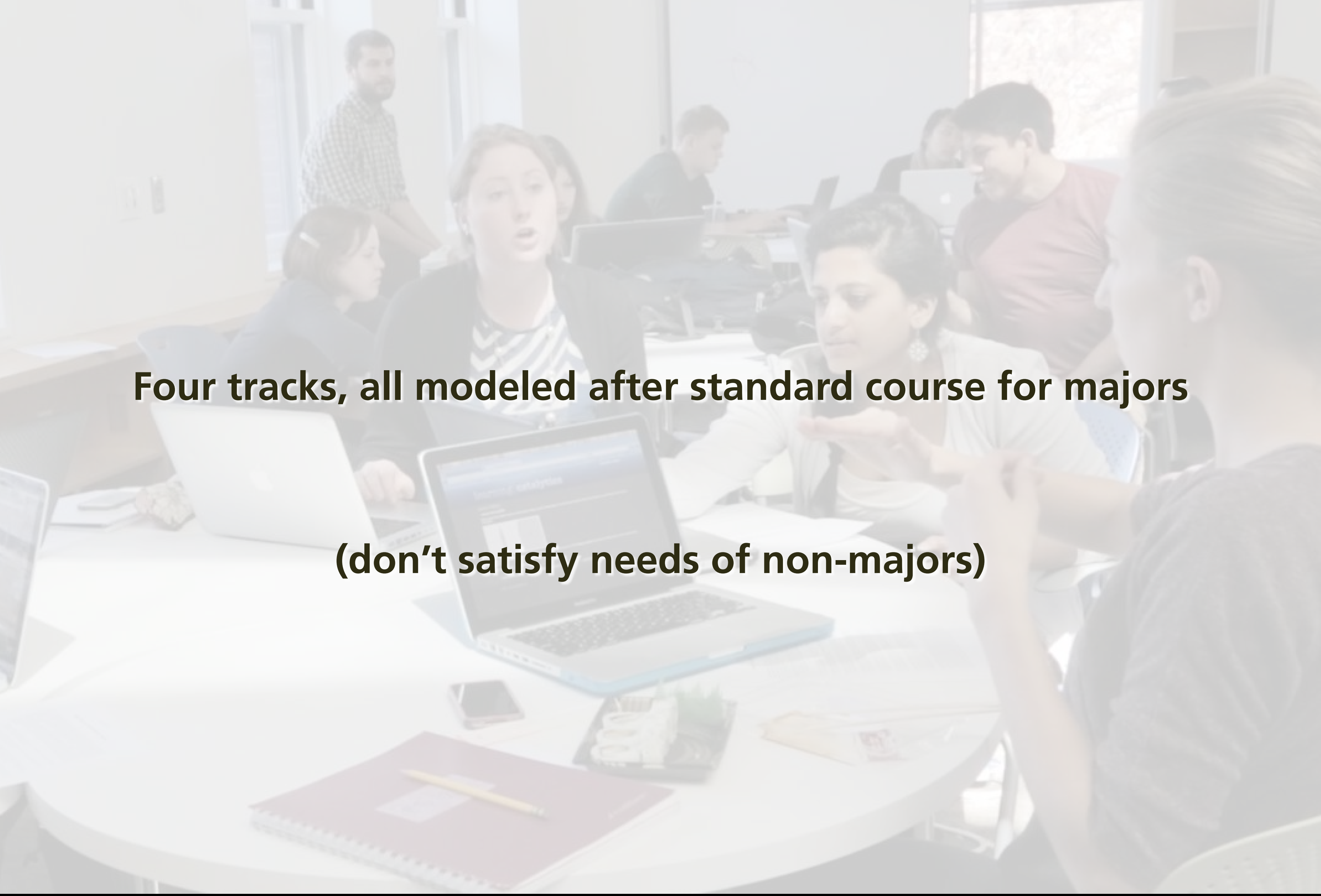
1 design **2 approach**

1 design 2 approach 3 results



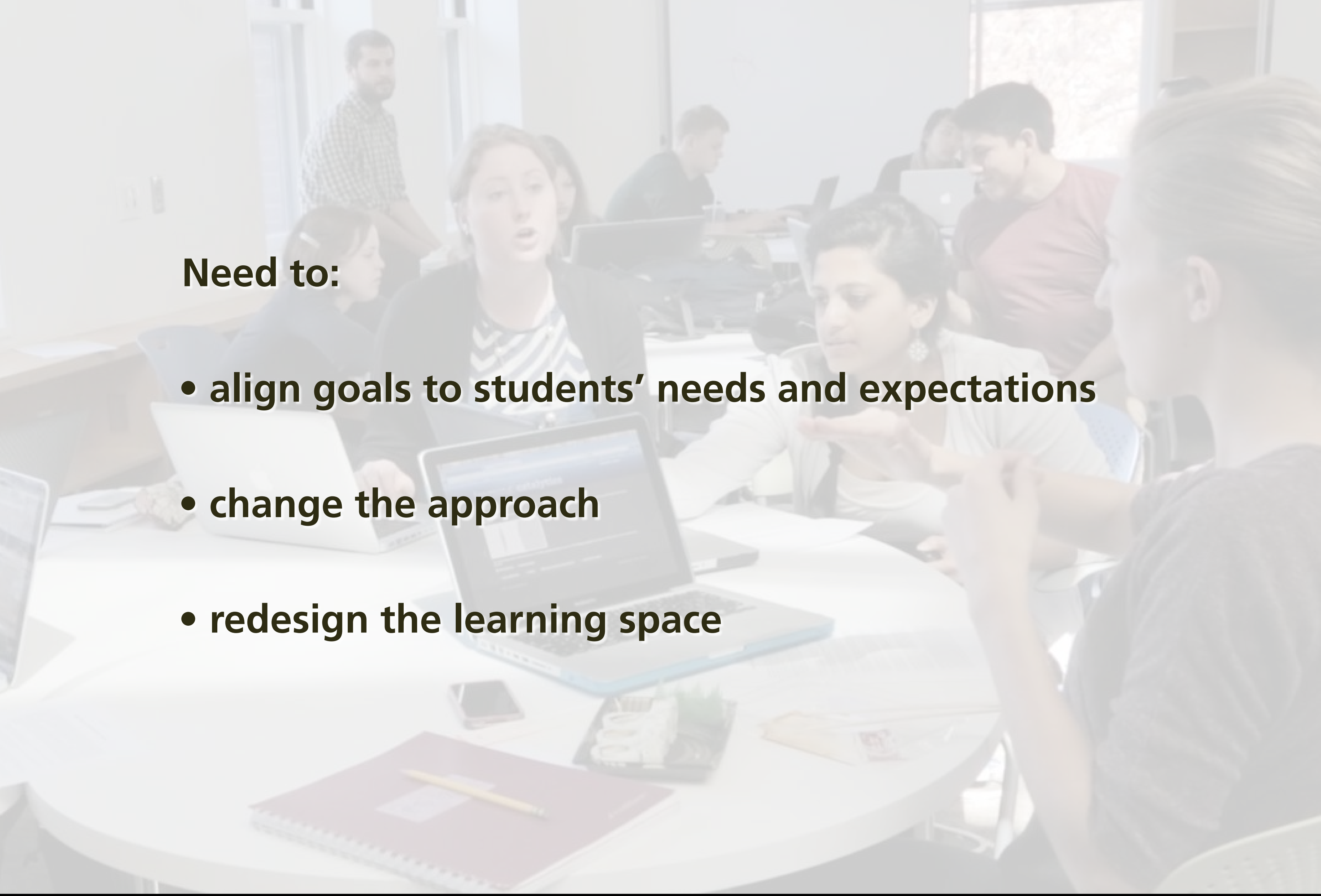
Four tracks, all modeled after standard course for majors

1 design



Four tracks, all modeled after standard course for majors

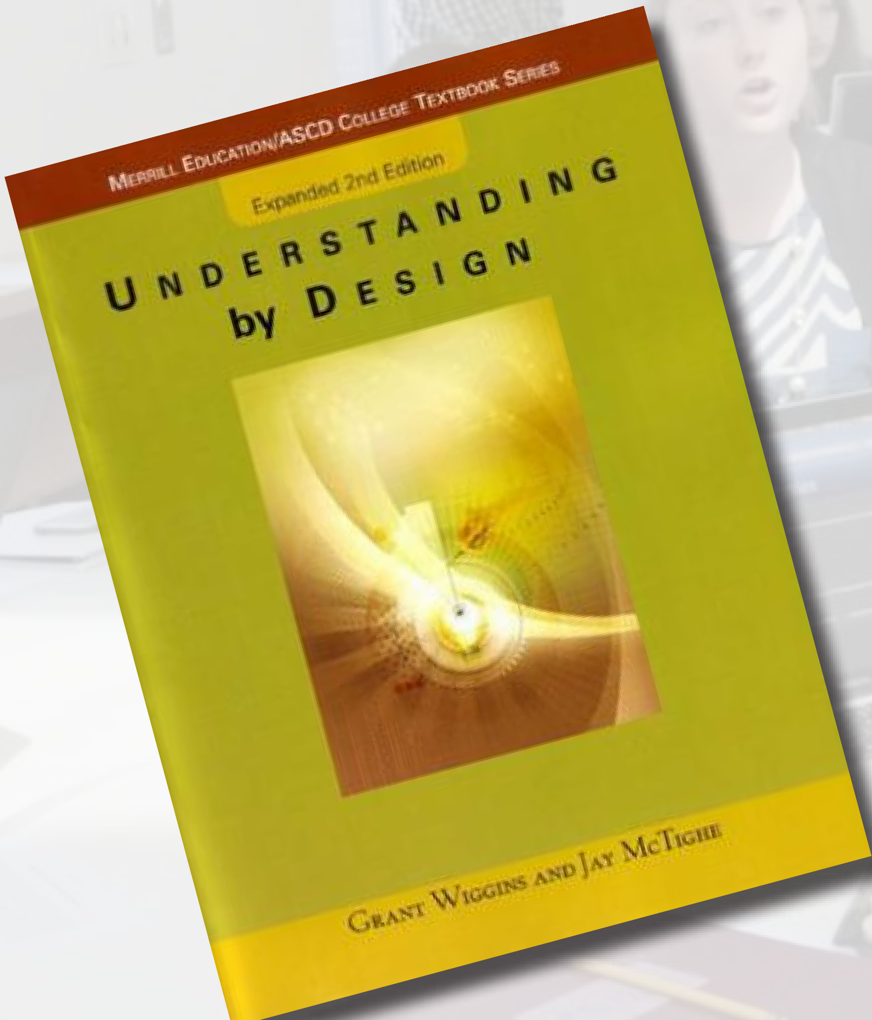
(don’t satisfy needs of non-majors)



Need to:

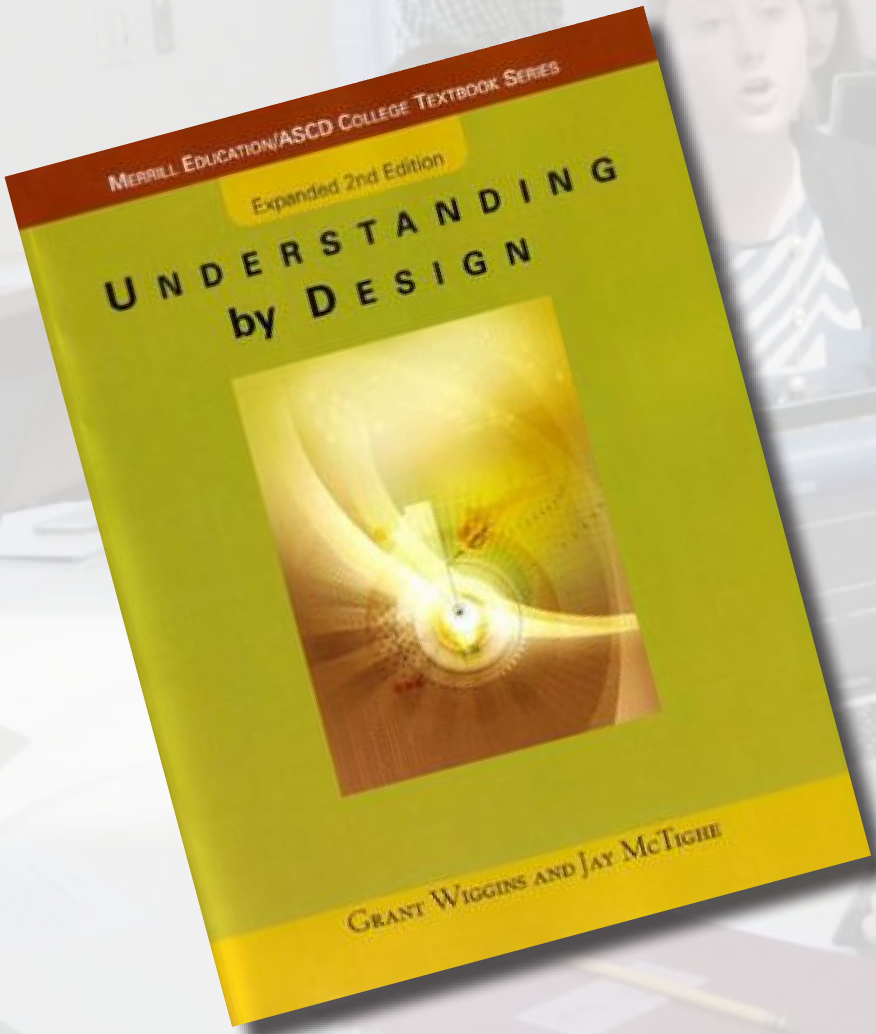
- align goals to students’ needs and expectations
- change the approach
- redesign the learning space

Setting learning goals



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

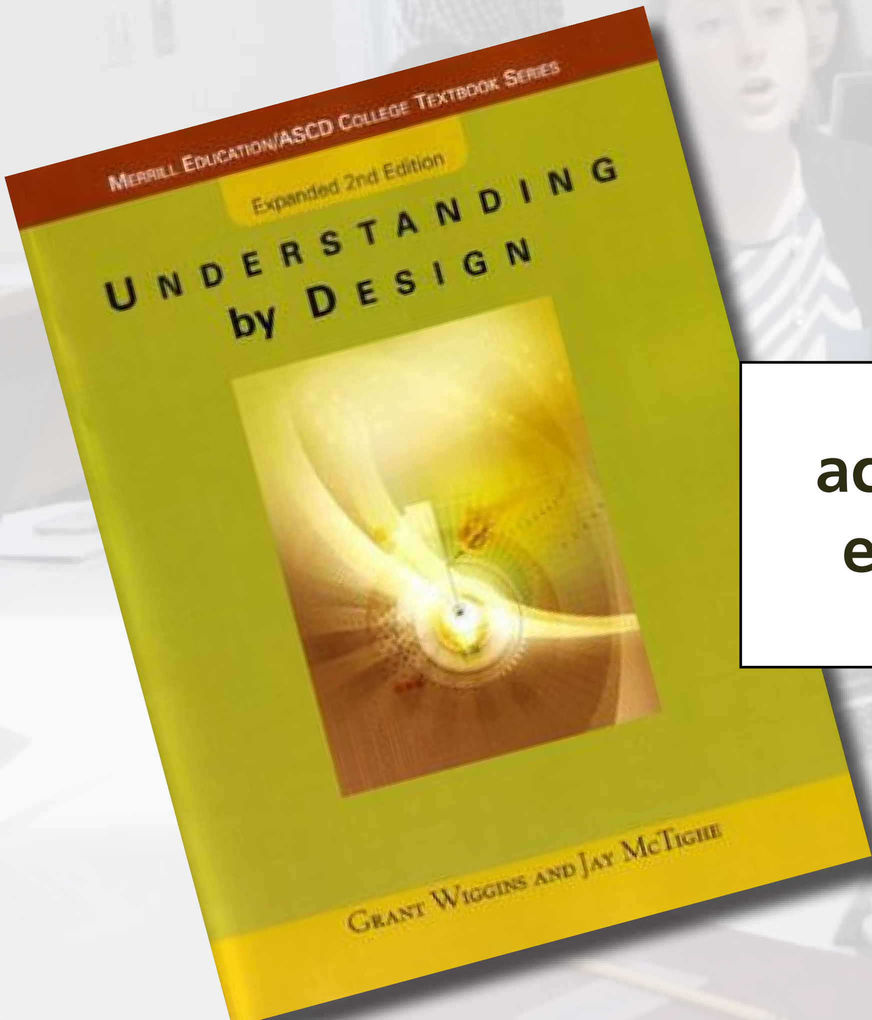
Backward design



desired outcomes

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

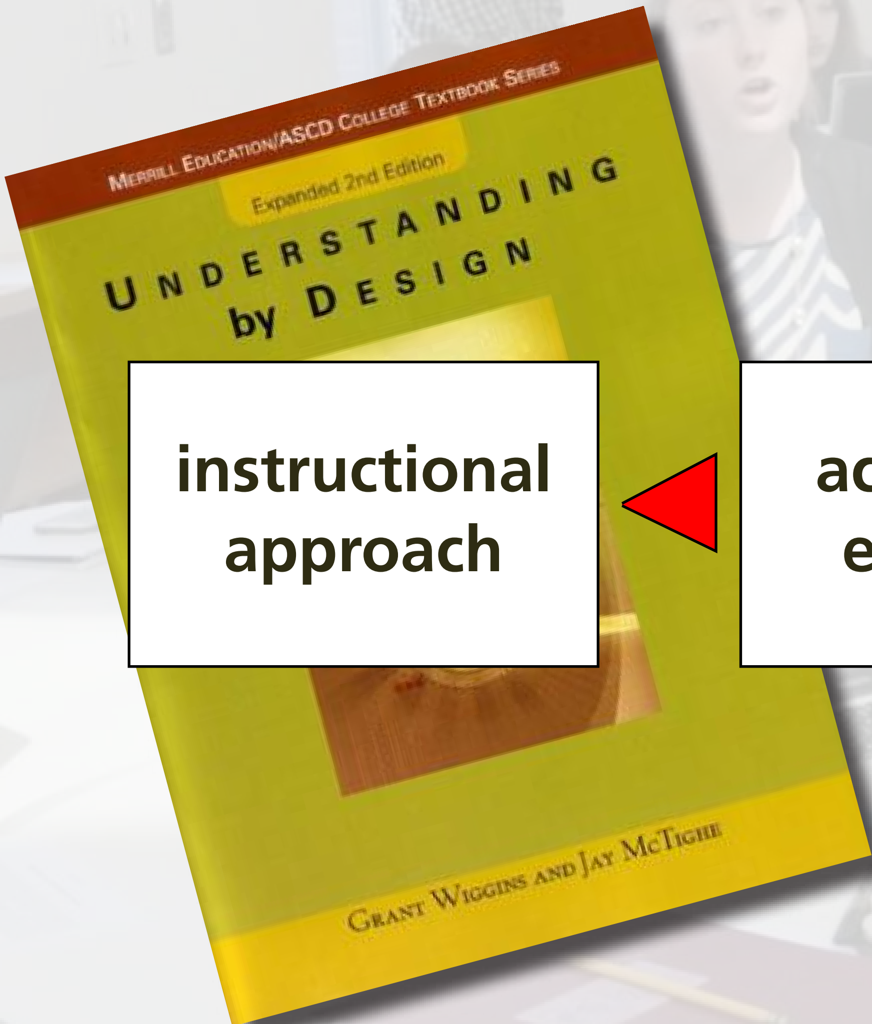
Backward design



acceptable evidence ◀ desired outcomes

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

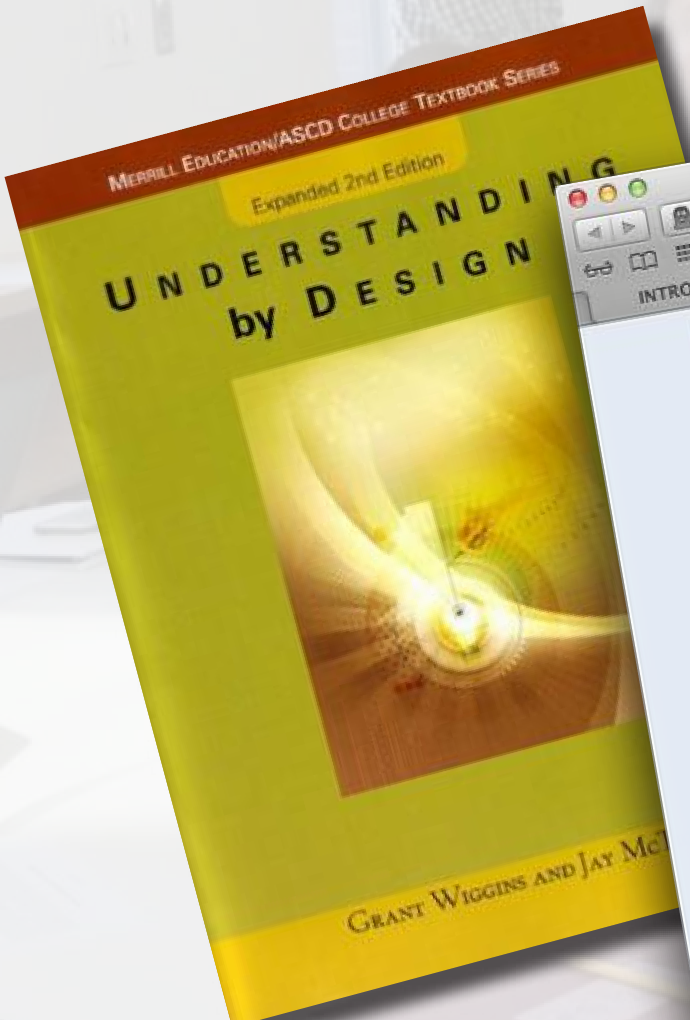
Backward design

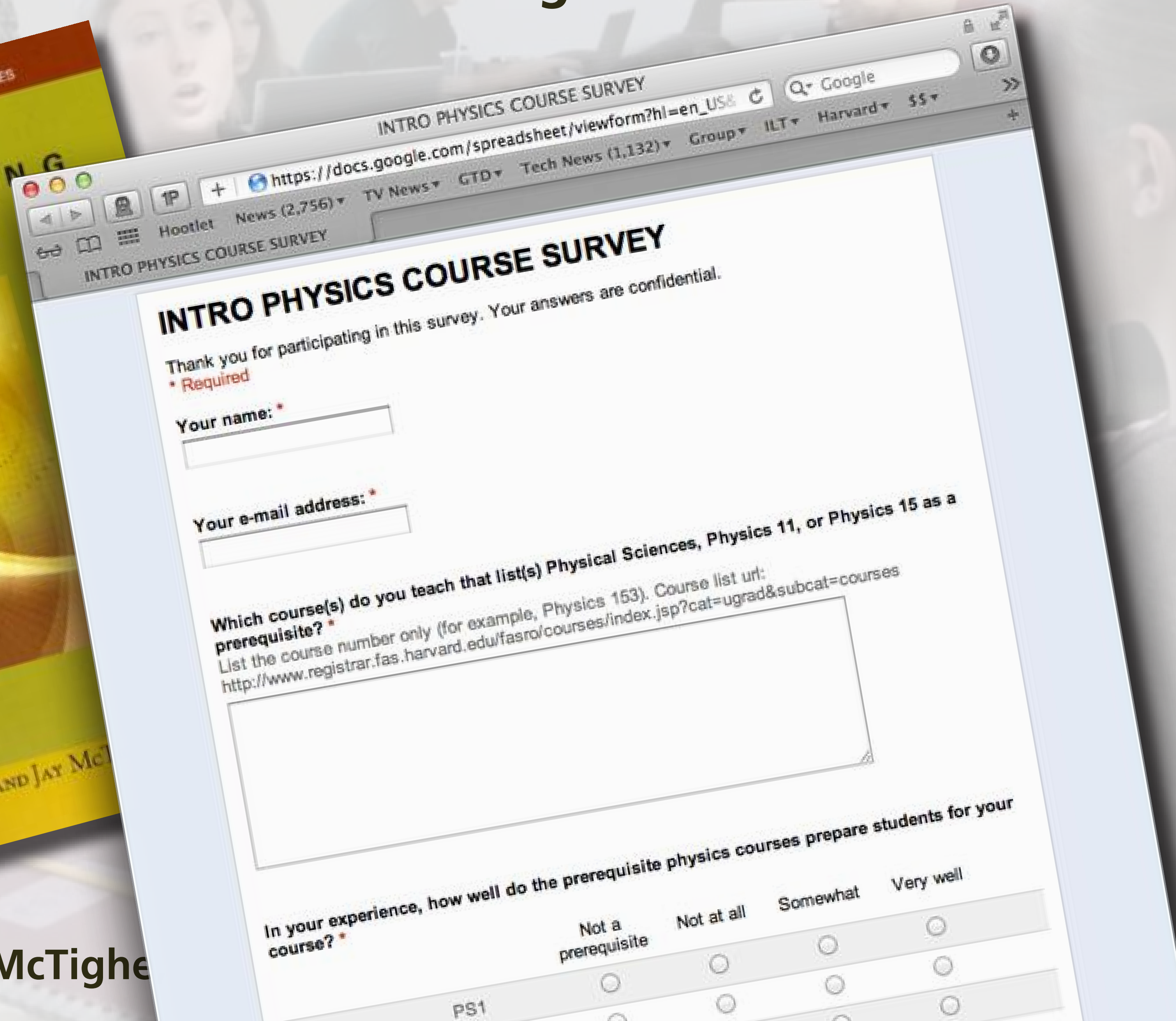


instructional approach ◀ acceptable evidence ◀ desired outcomes

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

Backward design





Grant Wiggins and Jay McTighe

1 design

competencies

course goals

COURSE GOALS

After successful completion of this course, you will be able to... (wit...

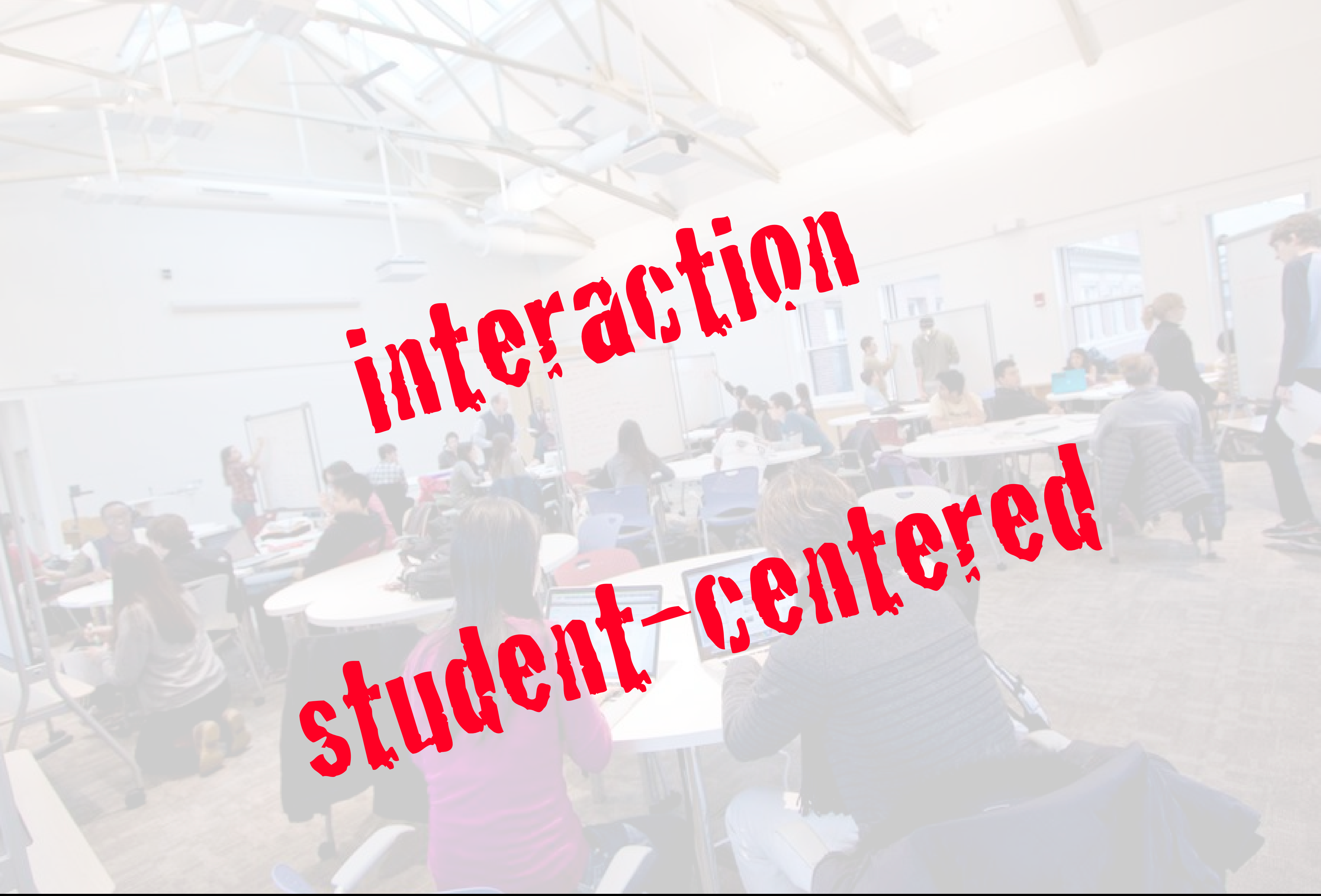
- Use independent study and research to tackle a problem
- Apply the scientific method to advance your knowledge and to desi...
- Use a variety of techniques to get a handle on problems: repres... perform ord... of magnitude estimates, use dimensional analysi... symmetries, evaluate limits, and/or relate the problem to cases w...
- Set up, solve, and interpret relevant equations
- Know how to evaluate the correctness of a solution
- Explain assumptions made in a model and know how to justify...
- Analyze a system, explain why it works, and how to optimize...
- Use information to build a case for a specific design or measu...
- Describe how a measurement is performed and the limitati...
- ...software to control simple experiments and accumulat...
- ...dentify sources of uncertainty, and minimiz...
- ...easurement in order to develo...
- ...ts and presentat...

content-specific goals

1 design

1 design

1 design



1 design

1 design

2 approach

CLASS → **ROOM**

1st exposure — deeper understanding

1 design

2 approach

1 design

2 approach

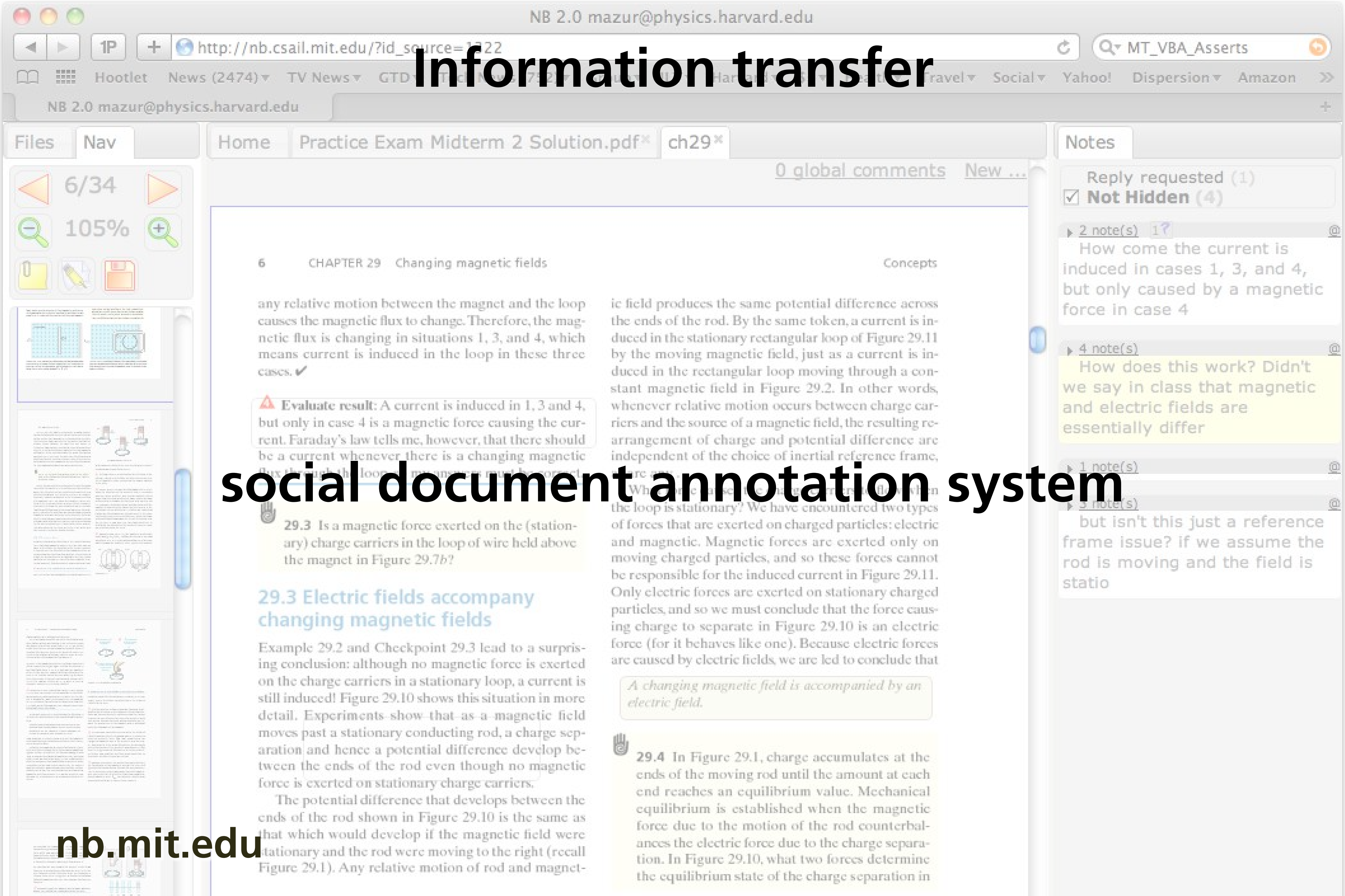
1 design

2 approach

Three major components:

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

Information transfer



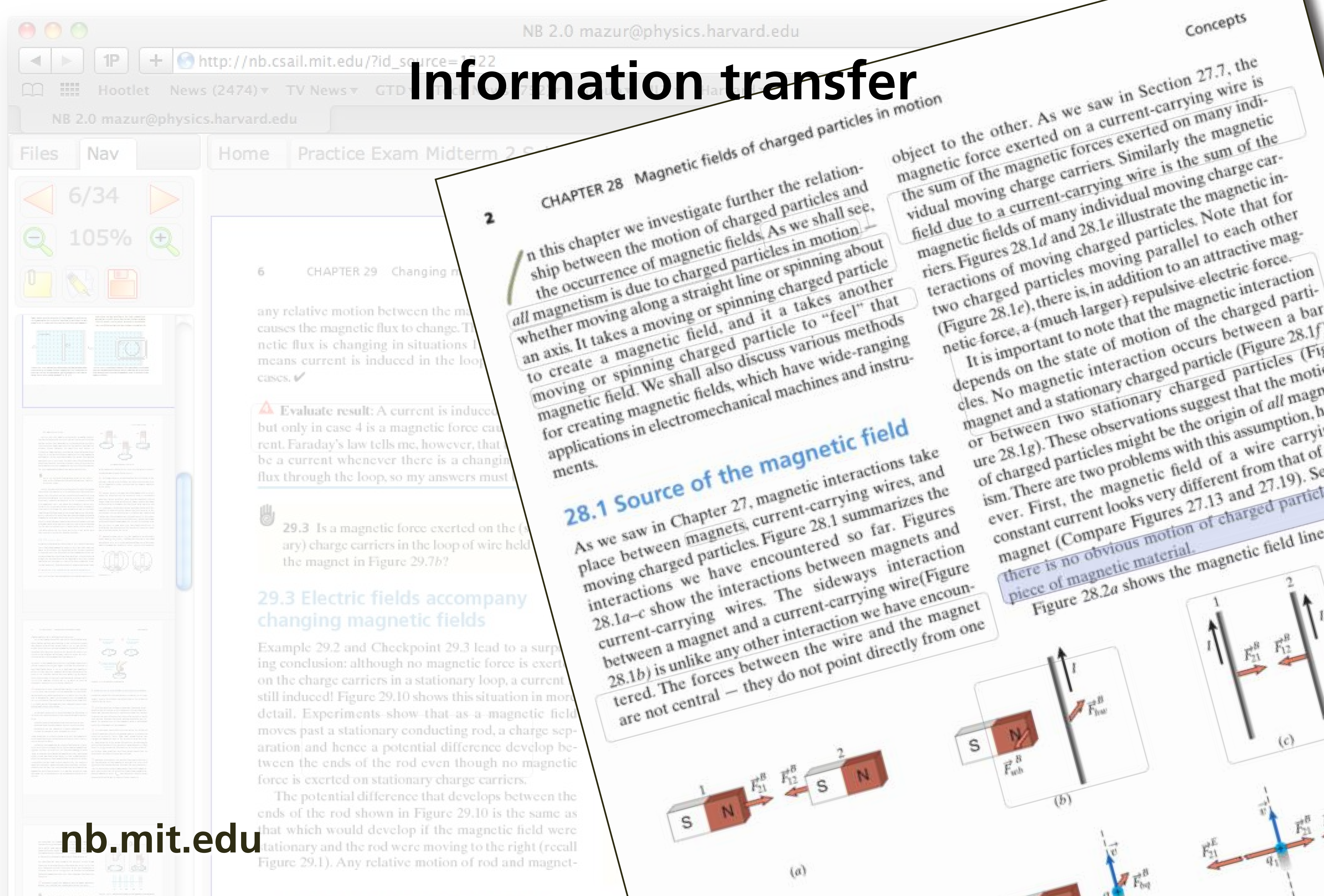
social document annotation system

nb.mit.edu

1 design

2 approach

Information transfer



nb.mit.edu

1 design

2 approach

Information transfer

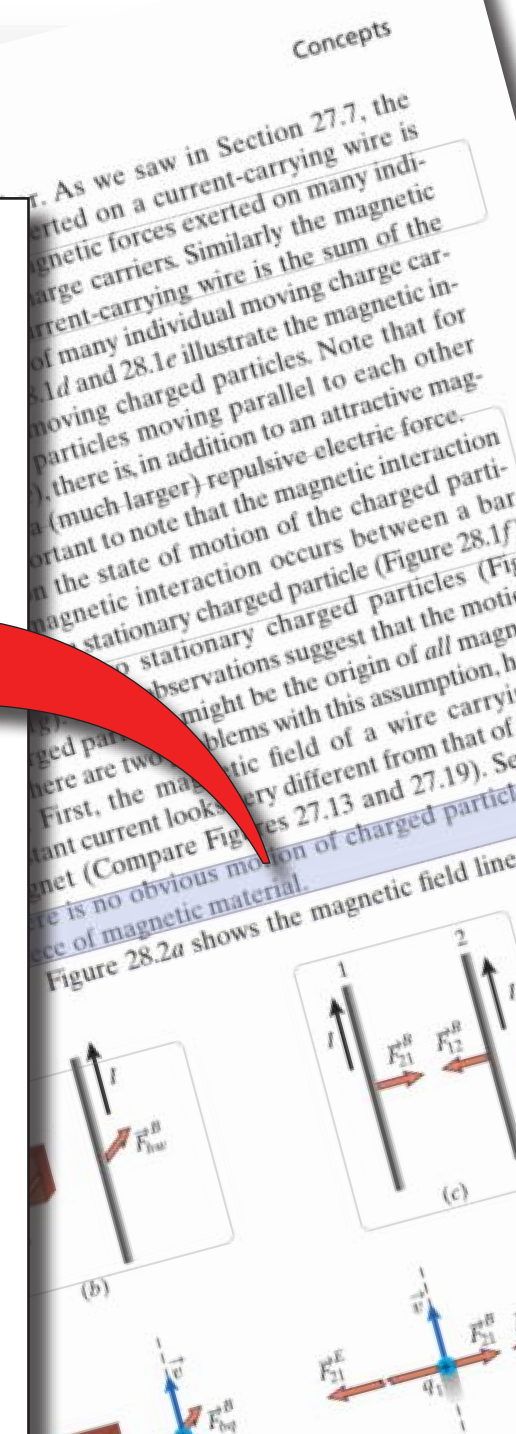
Student 1 – 25 Feb, 04:55PM
Yeah, this is where I'm confused. From the first paragraph: "It takes a moving or spinning charged particle to create a magnetic field..." however there is no obvious motion of charged particles in a piece of magnetic material (bar magnet for example?). How does this reconcile?

Student 2 – 26 Feb, 08:29PM
Maybe they are trying to say that there is no OBVIOUS motion, but they are i... moving via a current. Therefore, it meets their definition that it takes moving p... ticles to create a magnetic field

Student 3 – 2 Mar, 09:00AM
I agree that the motion is not "obvious" in that it is not visible to the naked eye. The cause must be atomic.

Student 2 – 2 Mar, 11:37AM
Oh the answers to this question kind of address my question above - I guess there isn't a force if the particle is stationary, but since even when an object is stationary (thus no obvious motion), there is a magnetic force. It's when everything, including the particles, are stationary that there is no obvious motion.

Student 4 – 4 Mar, 01:05PM
Is there ever a situation in reality where everything, even the particles are not ...



❶ design ❷ approach

Information transfer

over 30,000 annotations!

Student 1 – 25 Feb, 04:55PM
Yeah, this is where I'm confused. From the first paragr... "It takes a ...vi... or spinning charged particle to create a magnet... ..." ...we... there is ... o... ou... motion of charged particles in a piece of ma...etic ...ate...l (... magnet... e... ...ple?). How does this reconcile?

Student 2 – 26 ...eb, ...M
Ma... the... ...e...yin... ...ha... here is no O... ...S motion, but t...ey are in fact m... in... ...a ... ...ent. ...erefore, ... meets their de...ition that it takes ... ...ing par... tic... ... to ...eat... ...agne... fi...d

Stu... ...t ... – 2 Mar, 09:00AM
I agree t...at the motion is not "obvious" in tha... ...no... ...isibl... to t... naked eye. ...e cause must be atomic.

Student 2 – 2 M... ...37A...M
Oh the... ...rs t... ...i... ...ues...ion ...d ... ...ess ... ...estion above - I guess there isn't a force i... ...he ...ar... ... is ...at...ary, ...ut since even when an object is stationary (thus no ... ...s ... ...io... th... is a magnetic force. It's when everything, including the part...s, ... st...ionary that there is no obvious motion.

Student 4 – 4 Mar, 01:05PM
Is there ever a situation in reality where everything, even the particles are not ...

1 design

2 approach

In-class activities

In-class activities

2 weekly 3-hour class periods

In-class activities

blend of best practices

❶ design ❷ approach

In-class activities

estimation

blend of best practices

In-class activities

estimation

blend of best practices

reflection

In-class activities

estimation

blend of best practices

reflection

readiness assurance

1 design

2 approach

In-class activities

learning catalytics

estimation

blend of best practices

reflection

readiness assurance

In-class activities

learning catalytics

estimation

tutorials

readiness assurance

blend of best practices

reflection

In-class activities

learning catalytics

estimation

tutorials

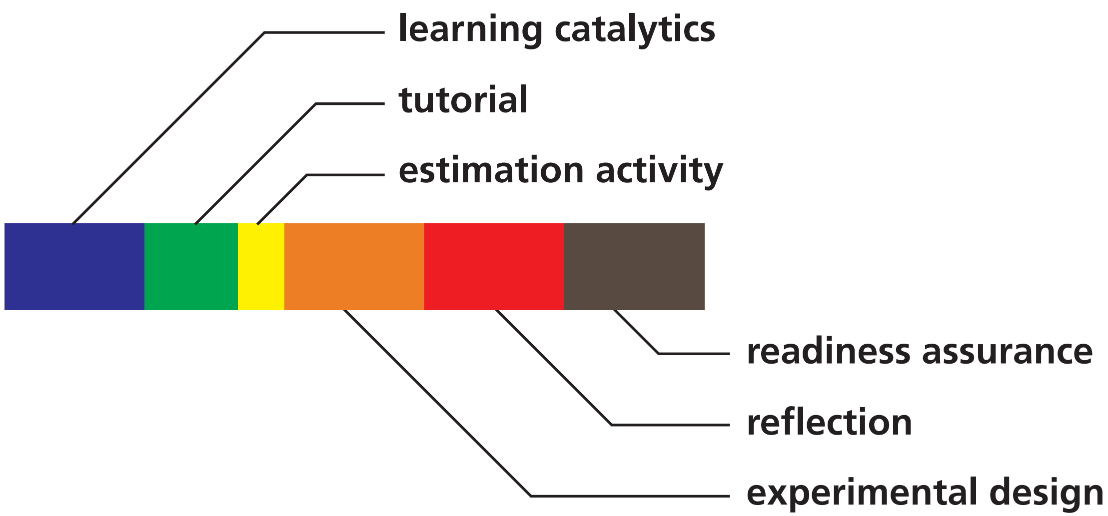
readiness assurance

blend of best practices

experimental design

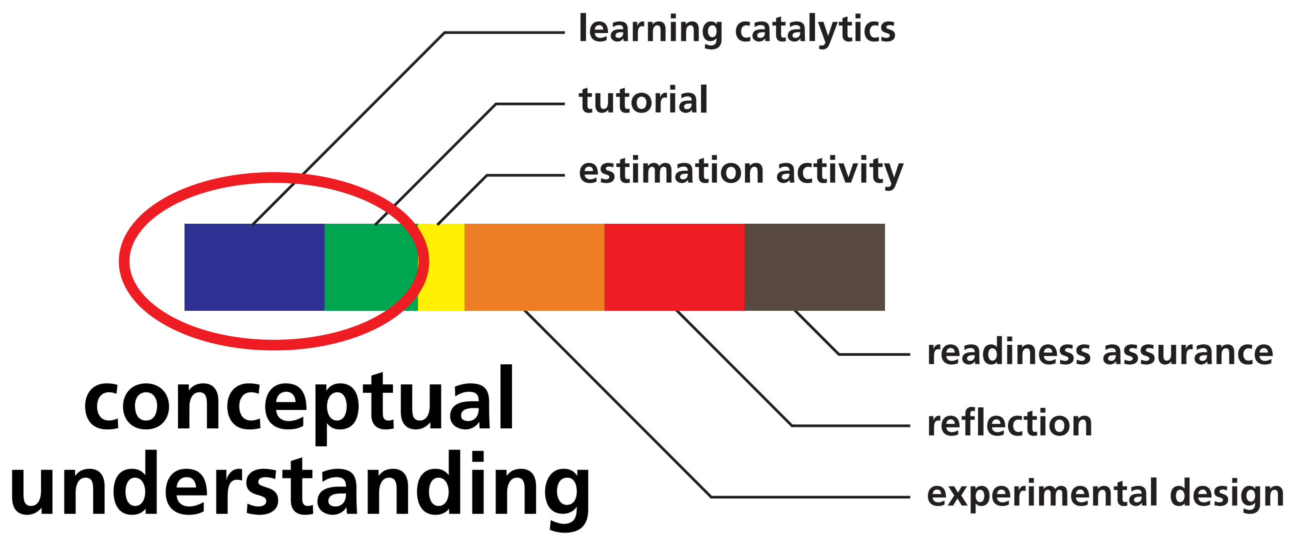
reflection

In-class activities

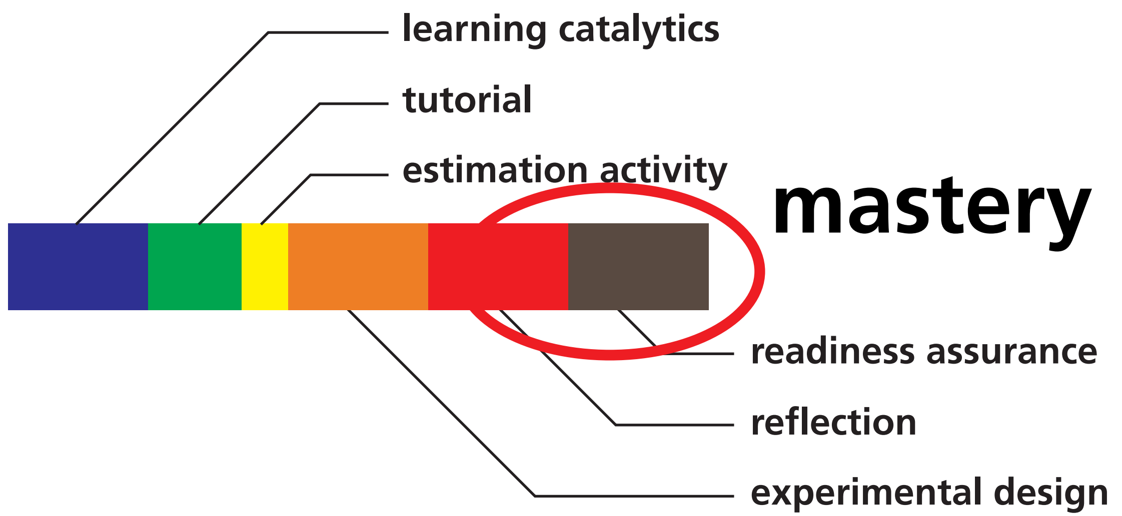


1 design 2 approach

In-class activities

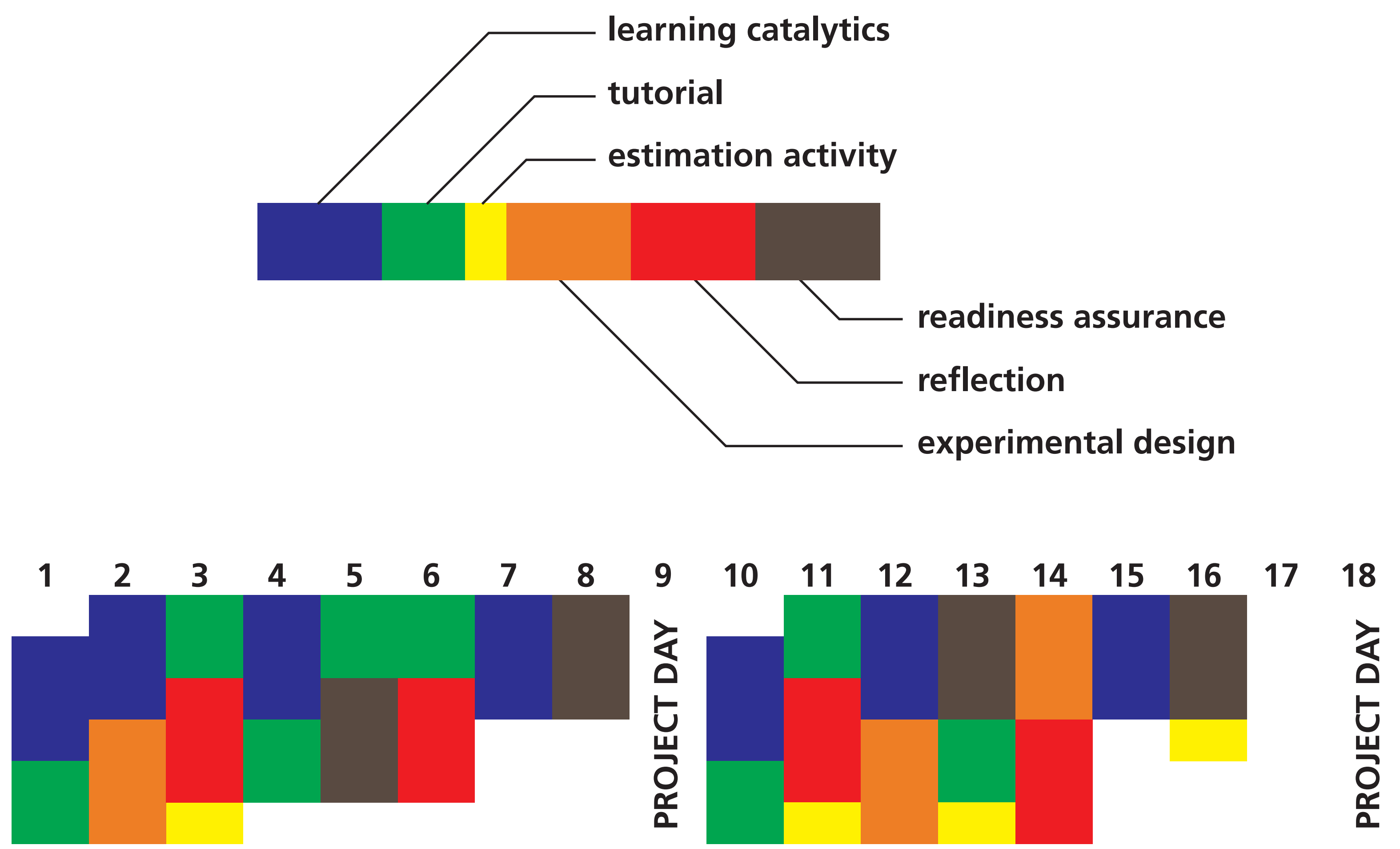


In-class activities



1 design **2** approach

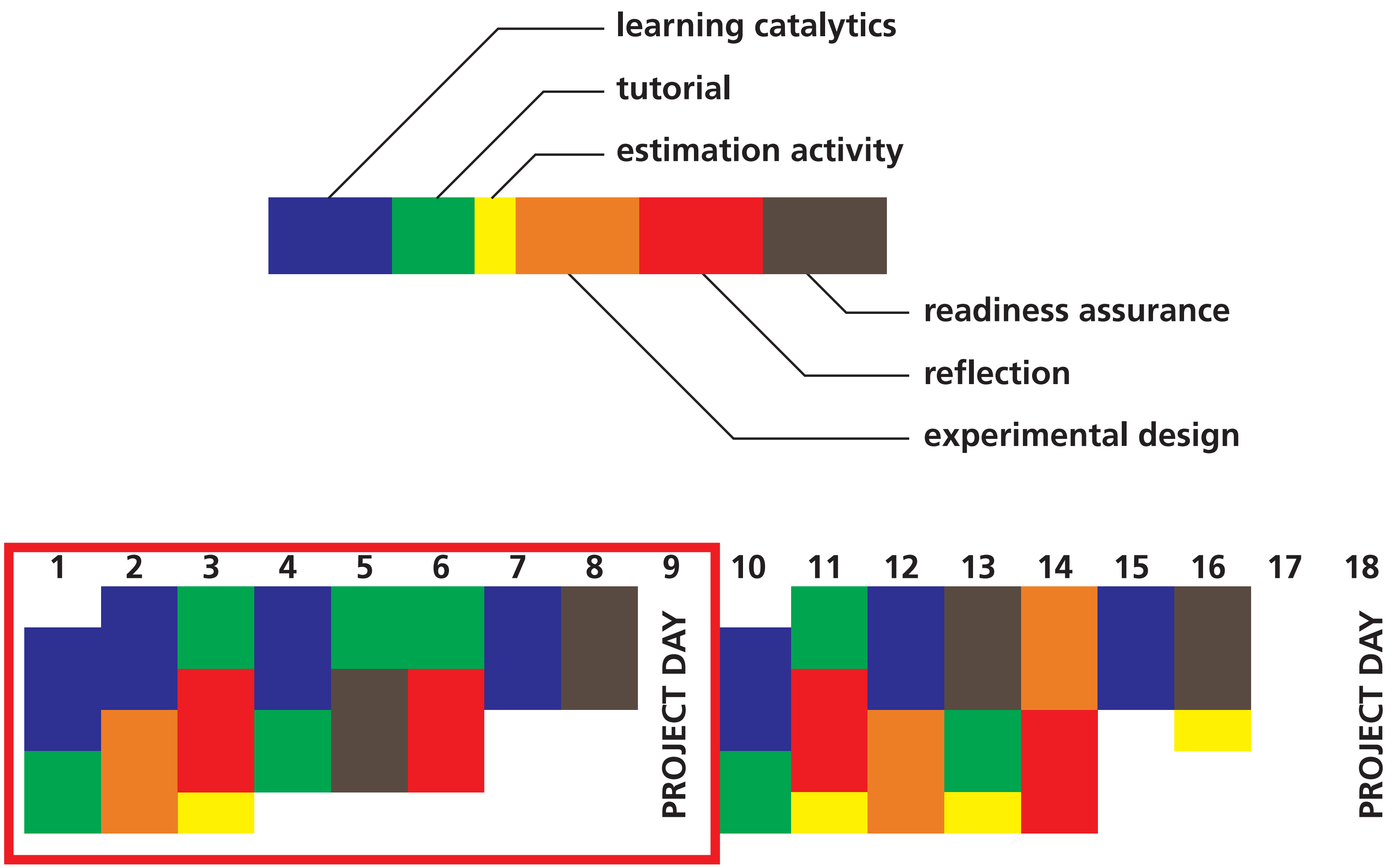
In-class activities



1 design

2 approach

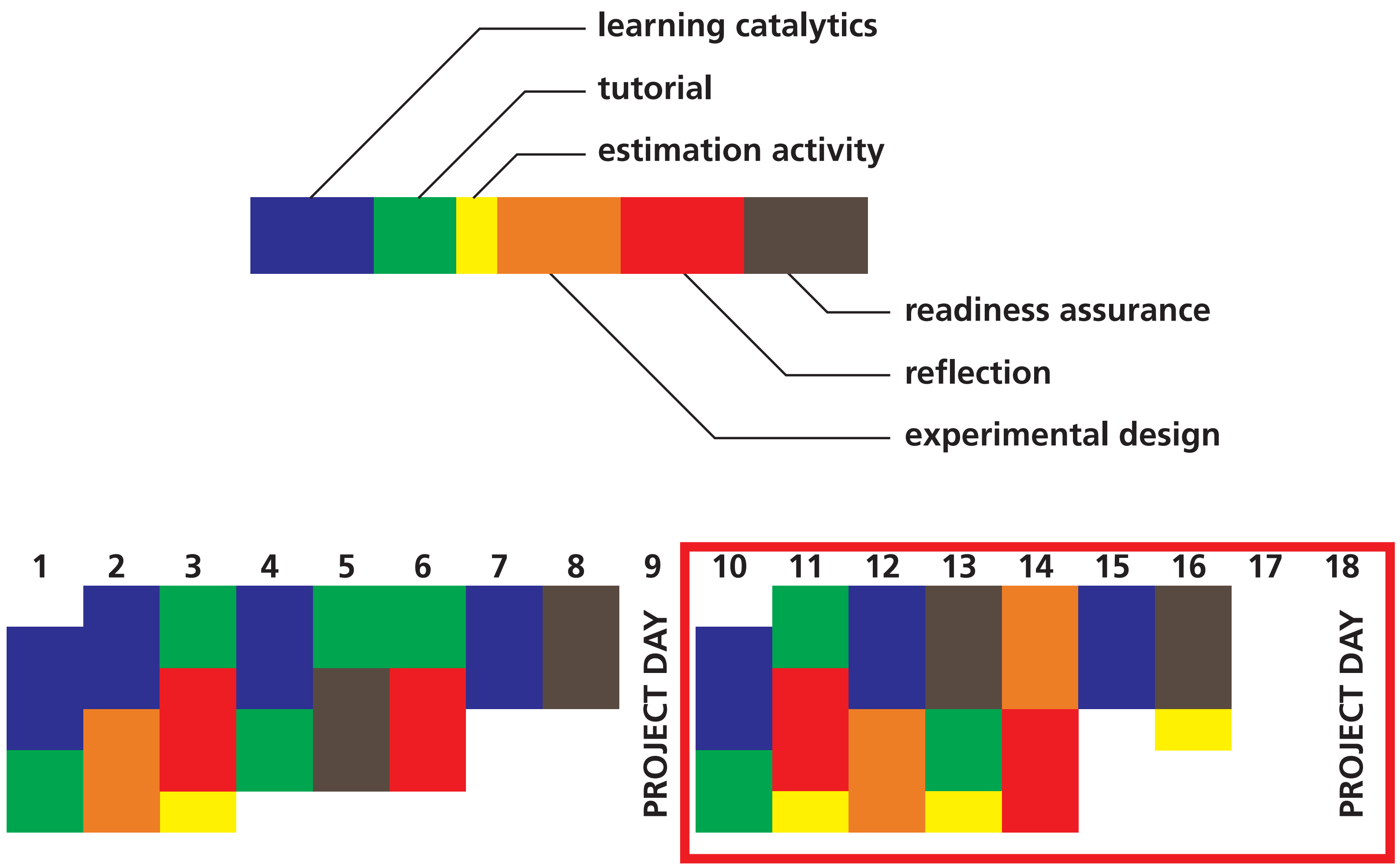
In-class activities



1 design

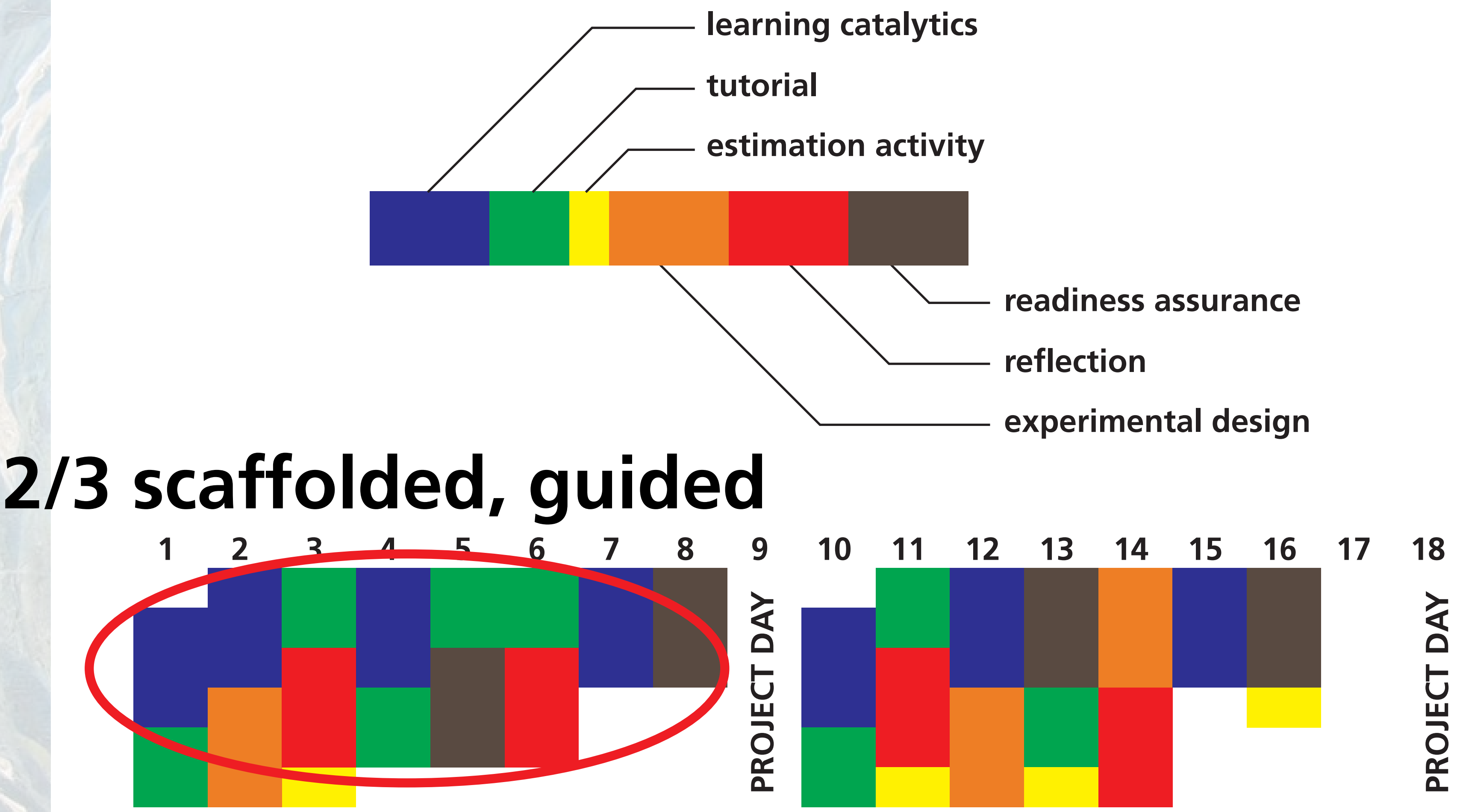
2 approach

In-class activities



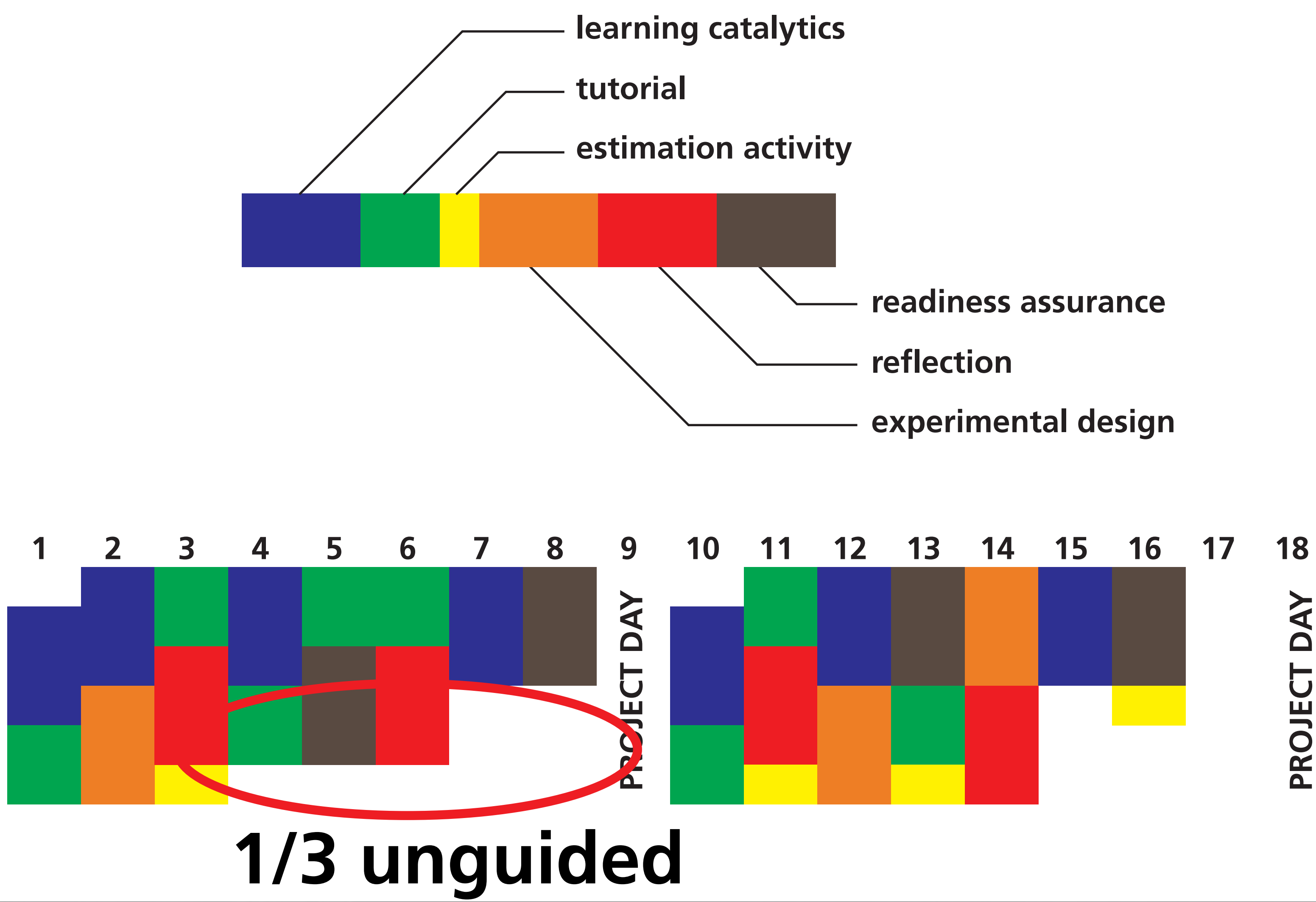
1 design
2 approach

In-class activities



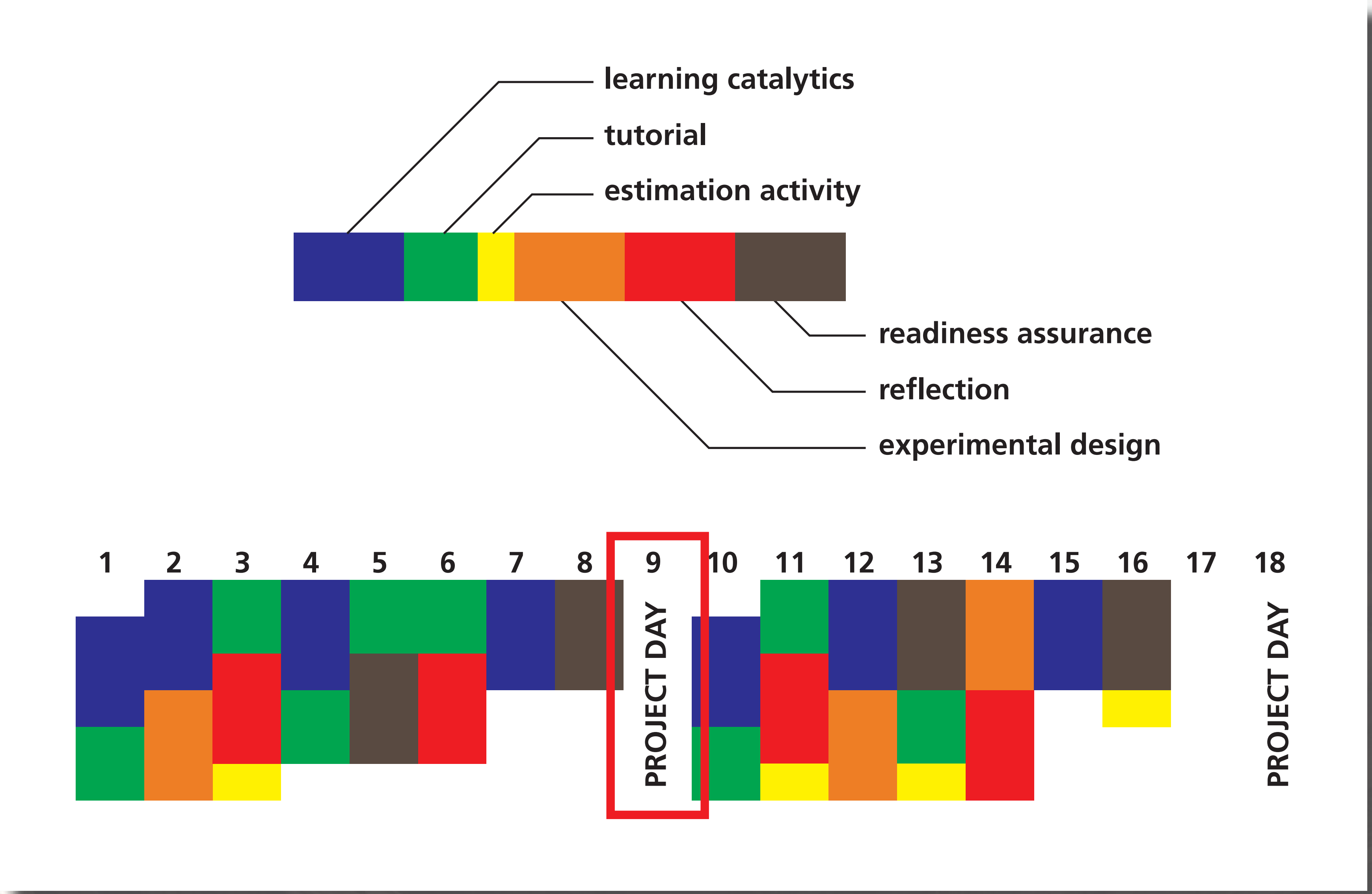
1 design 2 approach

In-class activities



1 design
2 approach

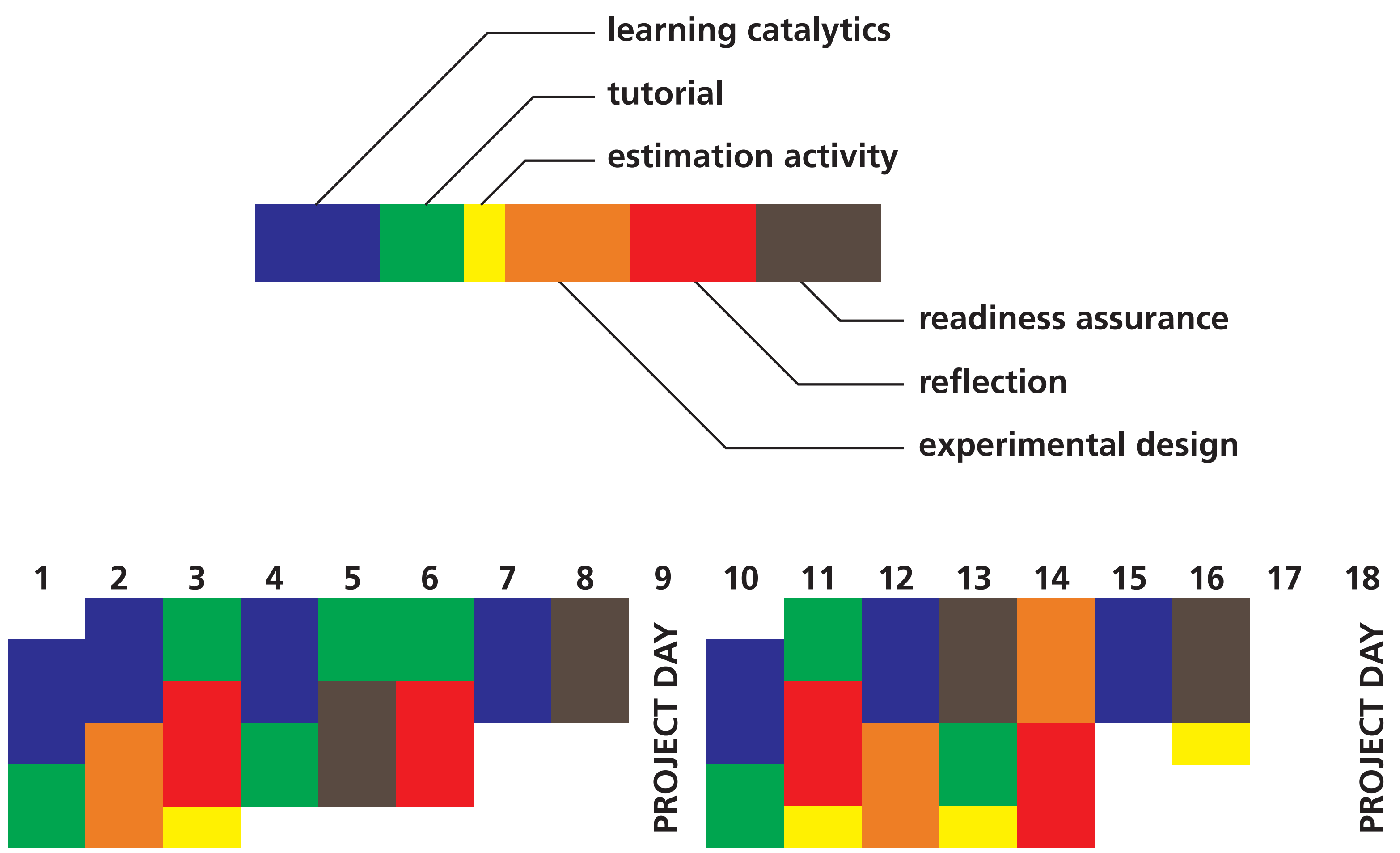
In-class activities



1 design

2 approach

In-class activities



learning catalytics

1 design

2 approach

learning catalytics

goal: develop conceptual understanding

learning catalytics

Eric Mazur | Harvard University | Log out

learning | catalytics

Courses Participate Review Classrooms Account Institutions Purchases Users Tour Help

optics i

current session: 766079 | 69 students

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

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

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

Deliver · Show all results

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

feedback & support

1 design

2 approach

1 design   2 approach

1 design 2 approach

❶ design ❷ approach

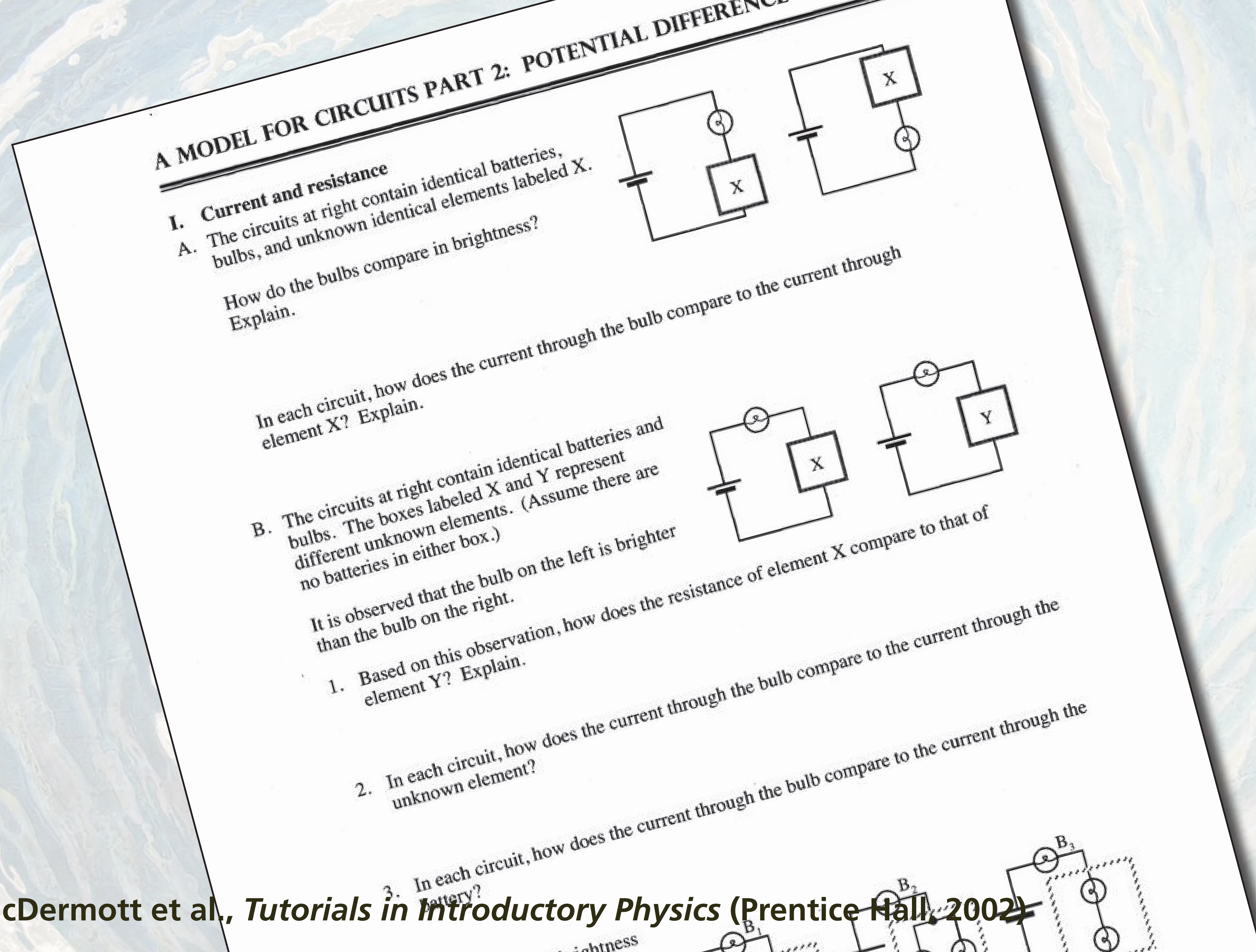
1 design

2 approach

tutorials

tutorials

goal: address documented misconceptions



A MODEL FOR CIRCUITS PART 2: POTENTIAL DIFFERENCE

I. Current and resistance

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

How do the bulbs compare in brightness? Explain.

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

B. The circuits at right contain identical batteries and bulbs. The boxes labeled X and Y represent 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.

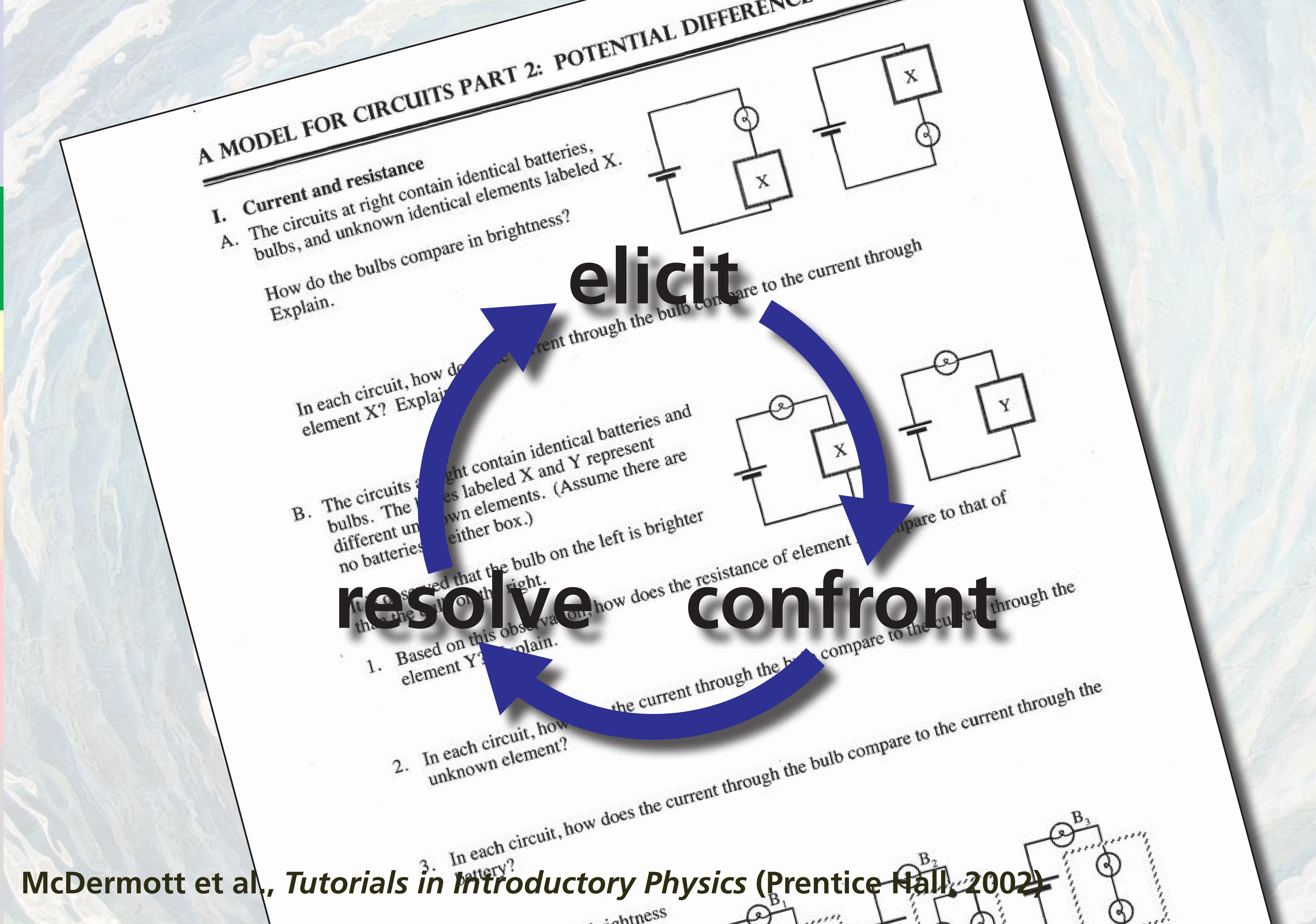
2. In each circuit, how does the current through the bulb compare to the current through the unknown element?

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

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

1 design

2 approach



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

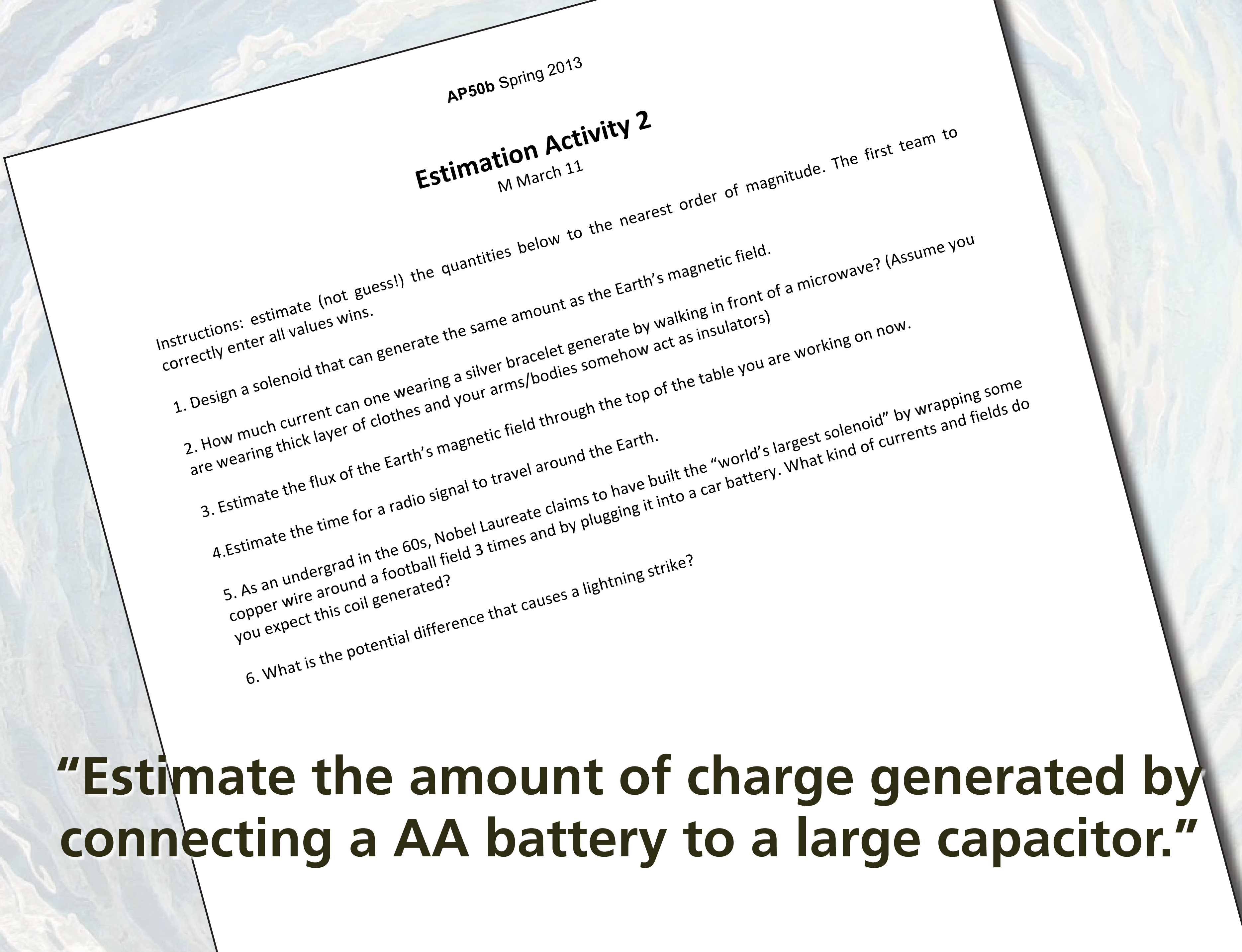
1 design

2 approach

estimation activity

estimation activity

goal: develop qualitative reasoning skills



AP50b Spring 2013

Estimation Activity 2

M March 11

Instructions: estimate (not guess!) the quantities below to the nearest order of magnitude. The first team to correctly enter all values wins.

1. Design a solenoid that can generate the same amount as the Earth's magnetic field.

2. How much current can one wearing a silver bracelet generate by walking in front of a microwave? (Assume you are wearing thick layer of clothes and your arms/bodies somehow act as insulators)

3. Estimate the flux of the Earth's magnetic field through the top of the table you are working on now.

4.Estimate the time for a radio signal to travel around the Earth.

5. As an undergrad in the 60s, Nobel Laureate claims to have built the "world's largest solenoid" by wrapping some copper wire around a football field 3 times and by plugging it into a car battery. What kind of currents and fields do you expect this coil generated?

6. What is the potential difference that causes a lightning strike?

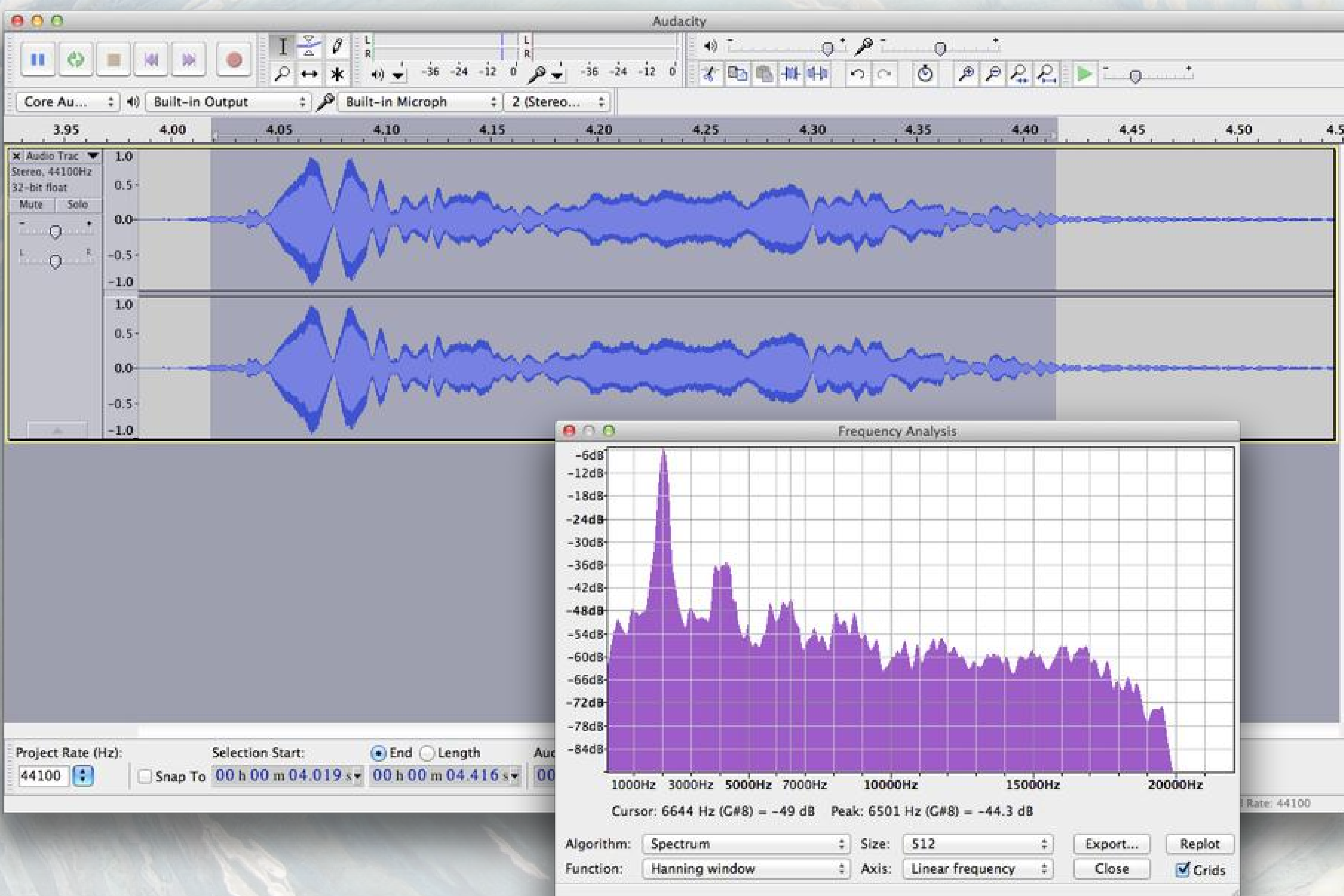
"Estimate the amount of charge generated by connecting a AA battery to a large capacitor."

1 design **2 approach**

experimental design activity

experimental design activity

goal: develop experimental skills



1 design

2 approach

homework reflection

goal: develop problem solving

and metacognitive skills

homework reflection

AP50b Fall 2013

Problem Set 1

due W Feb 6 in class

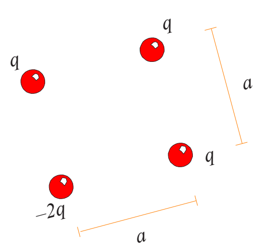
Instructions: as we need to quickly scan your work so we can return it before the end of class, please:

- 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 $q = 3.9{\times}10^{-4}$ C and $a = 6.9$ mm. What is the net force on the particle at the upper right corner due to the other three?



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

1 design **2** approach

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

1 design

2 approach

AP50b Spring 2014

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. The rubric mirrors the 4-step procedure used in all Worked Examples in the textbook (see also Section 1.8).

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**. You can consult the textbook and online resources, but you may not consult other people, nor collaborate with your peers. Treat this stage of the problem-solving process as an open-book/open-notes exam (except that your work done at home is not evaluated on correctness—see below). It's ok to try hard and not succeed at first, but you must attempt every problem. If you get stuck, try to describe your thought process so you are prepared for a discussion with your team in class. You may only use **blue or black ink**.

Team phase (in class): On the due date of the problem set, you will work with your team in class to complete, improve, and/or correct your solutions, and plan what you need to review (if anything). During this stage, you may only use **red ink** to write on your problem sets (pens will be provided in class). After the first 45 minutes, your team will be provided with a solution set which you may use to confirm your solutions. After an additional 45 minutes, your team must submit the team's corrected problem sets together with each team member's self-evaluation and indication which problems need to be reviewed in a Learning Clinic.

Important: It is the team's responsibility to ensure that *all* team members provide complete solutions, because your team's submitted problem sets will result in a shared team score. Therefore it is your responsibility to ensure that your entire team understands the material.

Scoring

Your problem set will be evaluated on the five domains below, using the standard 0–3 scale (3 = all problems; 2 = more than 70% of the problems, 1 = more than 50% of the problems, 0 = 50% or fewer of the problems). For the first two domains we will only evaluate the work you did **before coming to class** (anything not written in red).

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

Devise Plan Write down a plan of attack before diving into the solution. Break down the problem into smaller, manageable segments. Identify which physical relation...

Execute Plan Carry out your plan, explaining each step... Articulate your thought process... clearly defined, and... can co...

Eval...

1 design

2 approach

first two domains we will only evaluate the work you did **before coming to c**

Getting Started State the important information and summarize the pr Note any assumptions you're making.

Devise Plan Write down a plan of attack before diving into the sc smaller, manageable segments. Identify which physical r

Execute Plan Carry out your plan, explaining each step in writing. You Articulate your thought process at each step (including clearly defined, and your diagrams should be labeled. If y can complete this part in class with help from your team

Evaluate Plan Check each solution for reasonableness. There are many the symmetry of the solution, evaluate limiting or situations with known solutions, check units, use dimen of magnitude of an answer. If you get stuck on this step class with help from your team.

Reflection Clearly identify and explain any conceptual errors yo worked on the problem alone, as well as any mechanic completed in class.

first two domains we will only evaluate the work you did **before coming to c**

4-step procedure

Getting Started	State the important information and summarize the pr Note any assumptions you're making.
Devise Plan	Write down a plan of attack before diving into the so smaller, manageable segments. Identify which physical r
Execute Plan	Carry out your plan, explaining each step in writing. You Articulate your thought process at each step (including clearly defined, and your diagrams should be labeled. If y can complete this part in class with help from your team
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Reflection	Clearly identify and explain any conceptual errors yo worked on the problem alone, as well as any mechanic completed in class.

1 design

2 approach

first two domains we will only evaluate the work you did **before coming to c**

individual evaluation

Getting Started	State the important information and summarize the pr Note any assumptions you're making.
Devise Plan	Write down a plan of attack before diving into the so smaller, manageable segments. Identify which physical r
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1 design

2 approach

first two domains we will only evaluate the work you did **before coming to c**

Getting Started State the important information and summarize the pr
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clearly defined, and your diagrams should be labeled. If y
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team evaluation

Evaluate Plan Check each solution for reasonableness. There are man
the symmetry of the solution, evaluate limiting or
situations with known solutions, check units, use dimen
of magnitude of an answer. If you get stuck on this step
class with help from your team.

Reflection Clearly identify and explain any conceptual errors yo
worked on the problem alone, as well as any mechanic
completed in class.

1 design

2 approach

first two domains we will only evaluate ... work you did **before coming to c**

Getting Started — State the important information and summarize the pr... ...u're making.

Devise Plan — Write down a plan of attack ... smaller, manageable segments ...

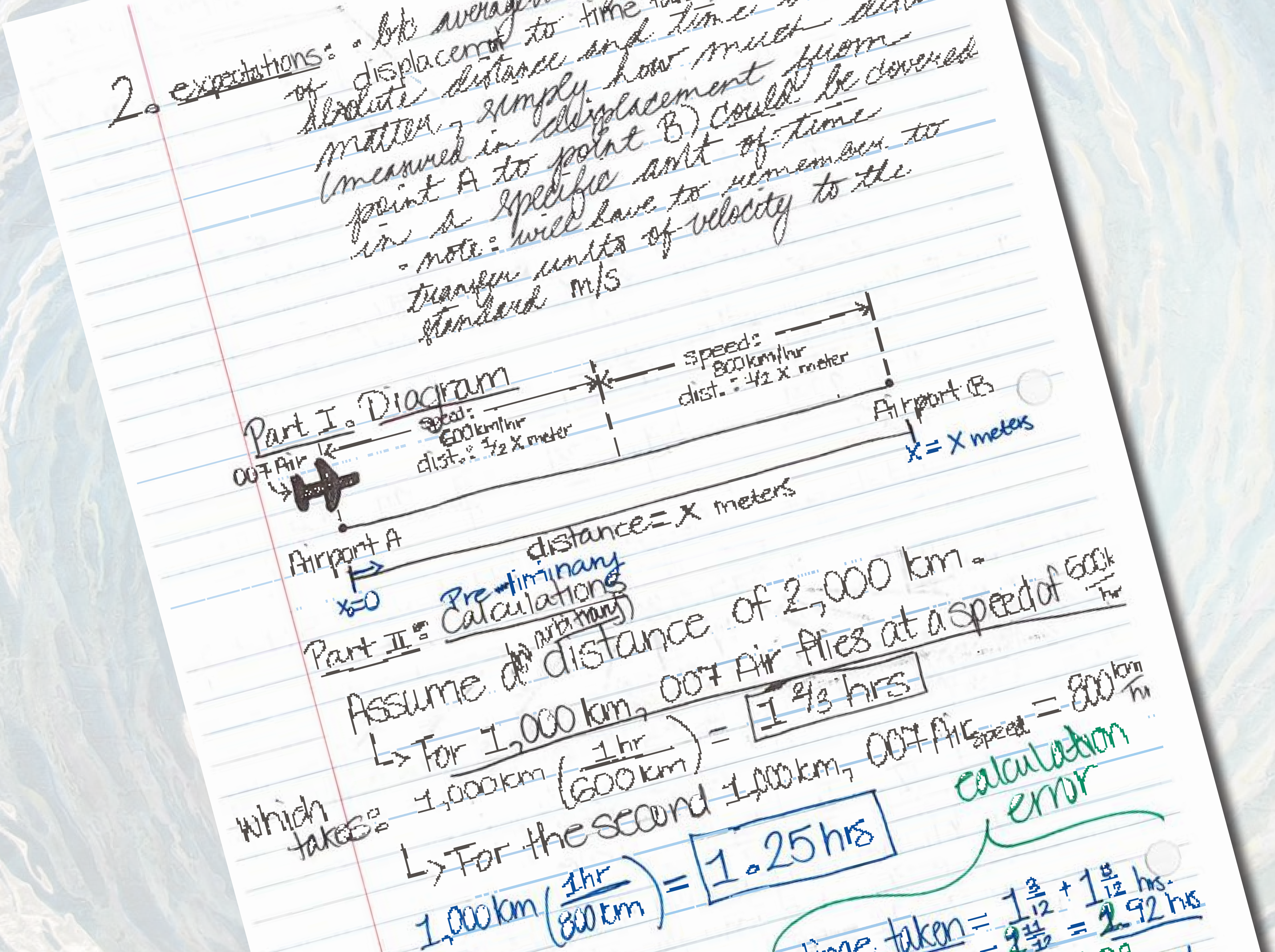
Execute Plan — Carry out your plan ... Articulate your thought process at each step (including ... should be labeled. If ... in class with help from your team

Evaluate Plan — Check each solution for reasonableness. There are man... the symmetry of the solution, evaluate limiting or ... situations with known solutions, check units, use dimen... of magnitude of an answer. If you get stuck on this step ... class with help from your team.

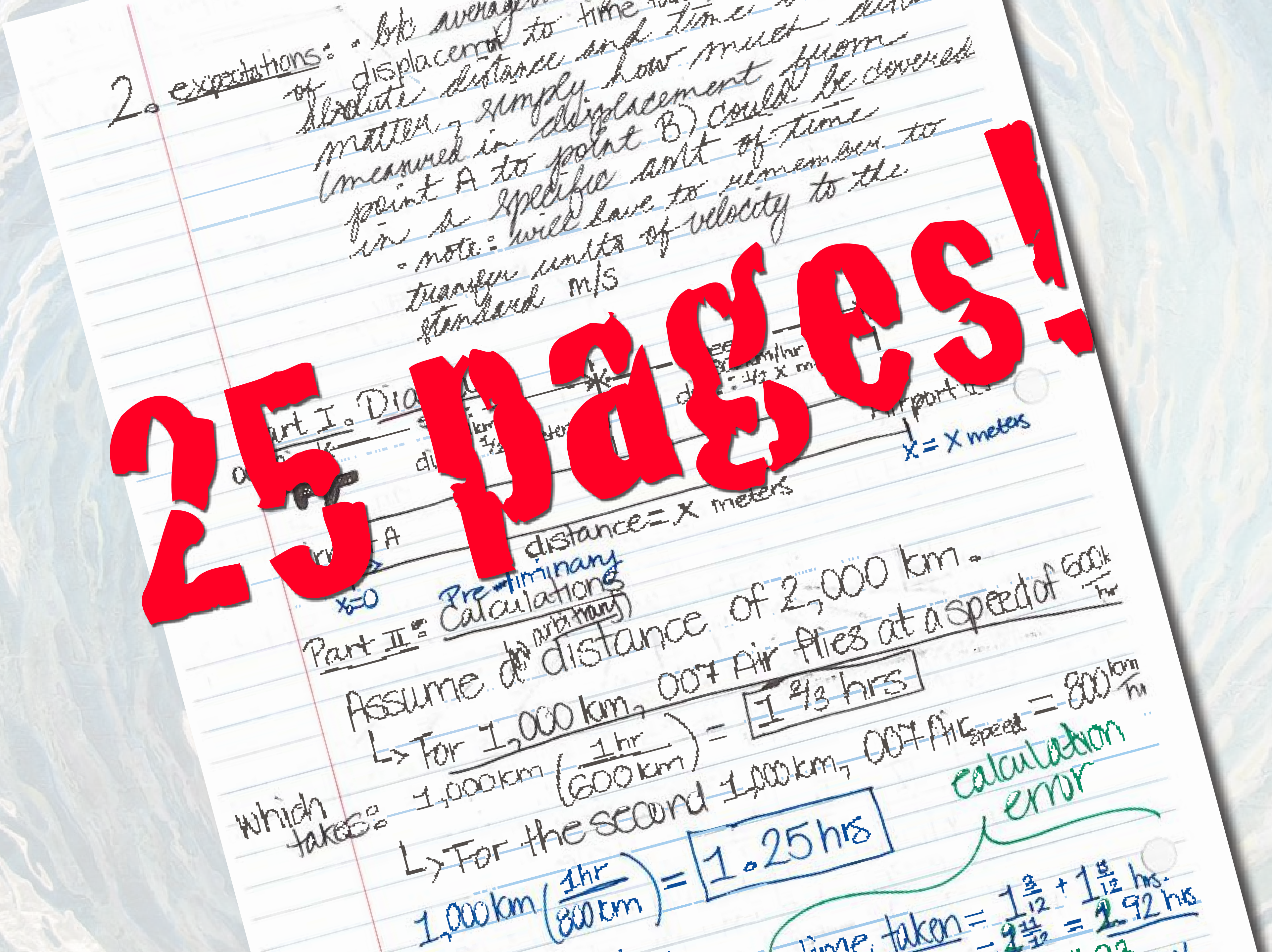
Reflection — Clearly identify and explain any conceptual errors yo... worked on the problem alone, as well as any mechanic... completed in class.

social responsibility

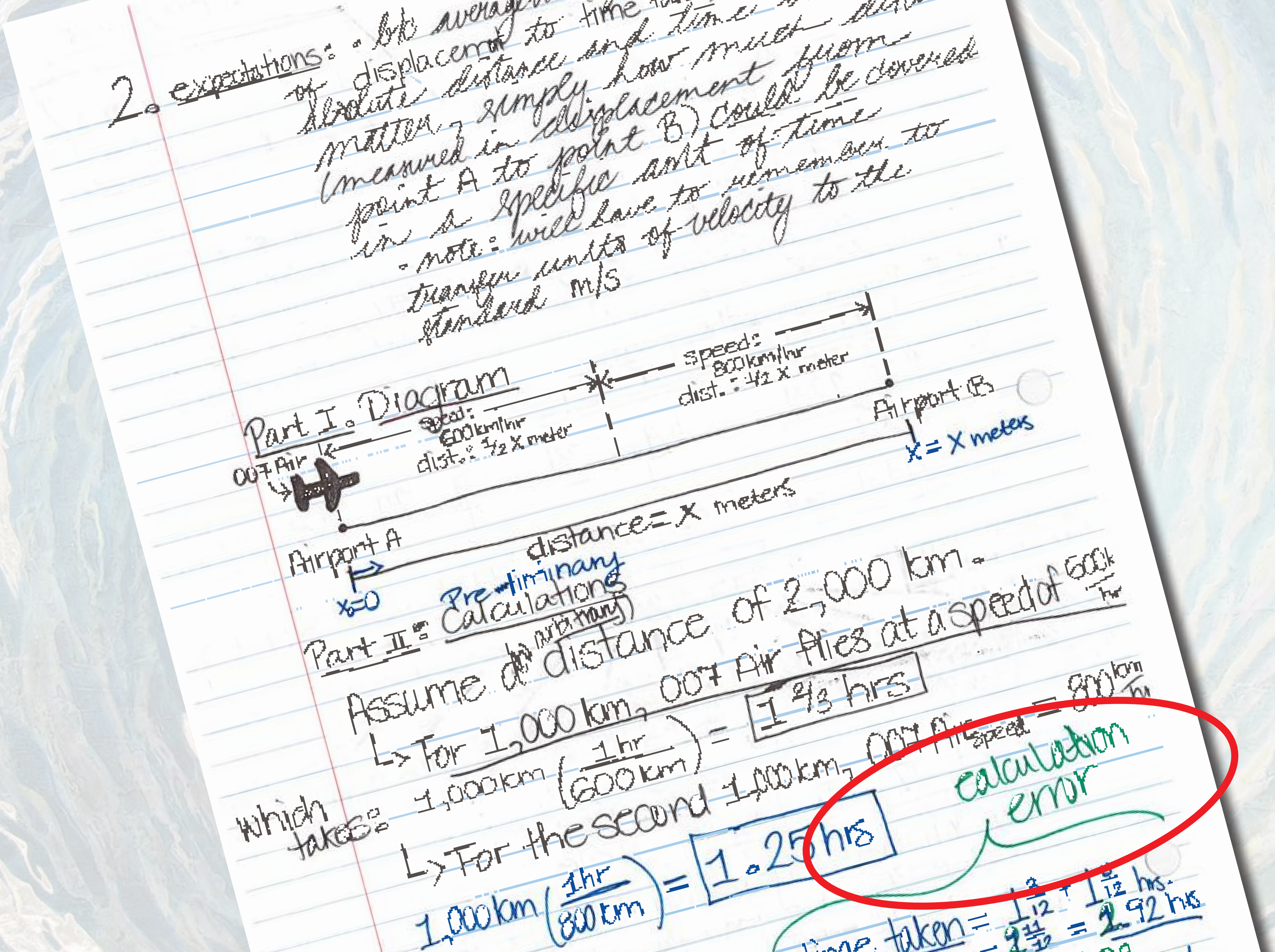
team evaluation



1 design 2 approach



1 design 2 approach


2. expectations: • b/c average … of displacement to time … absolute distance and time … matter, simply how much … (measured in displacement from point A to point B) could be covered in a specific amt of time
• note: will have to remember to transfer units of velocity to the standard m/s

Part II: Preliminary Calculations
Assume a (arbitrary) distance of 2,000 km.
007 Air flies at a speed of 600 km/hr
↳ For 1,000 km, which takes: 1,000 km (1 hr / 600 km) = 1 2/3 hrs
↳ For the second 1,000 km, 007 Air's speed = 800 km/hr
1,000 km (1 hr / 800 km) = 1.25 hrs
calculation error
time taken = 1 8/12 + 1 3/12 hrs = 2 11/12 = 2.92 hrs

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”

readiness assurance activity

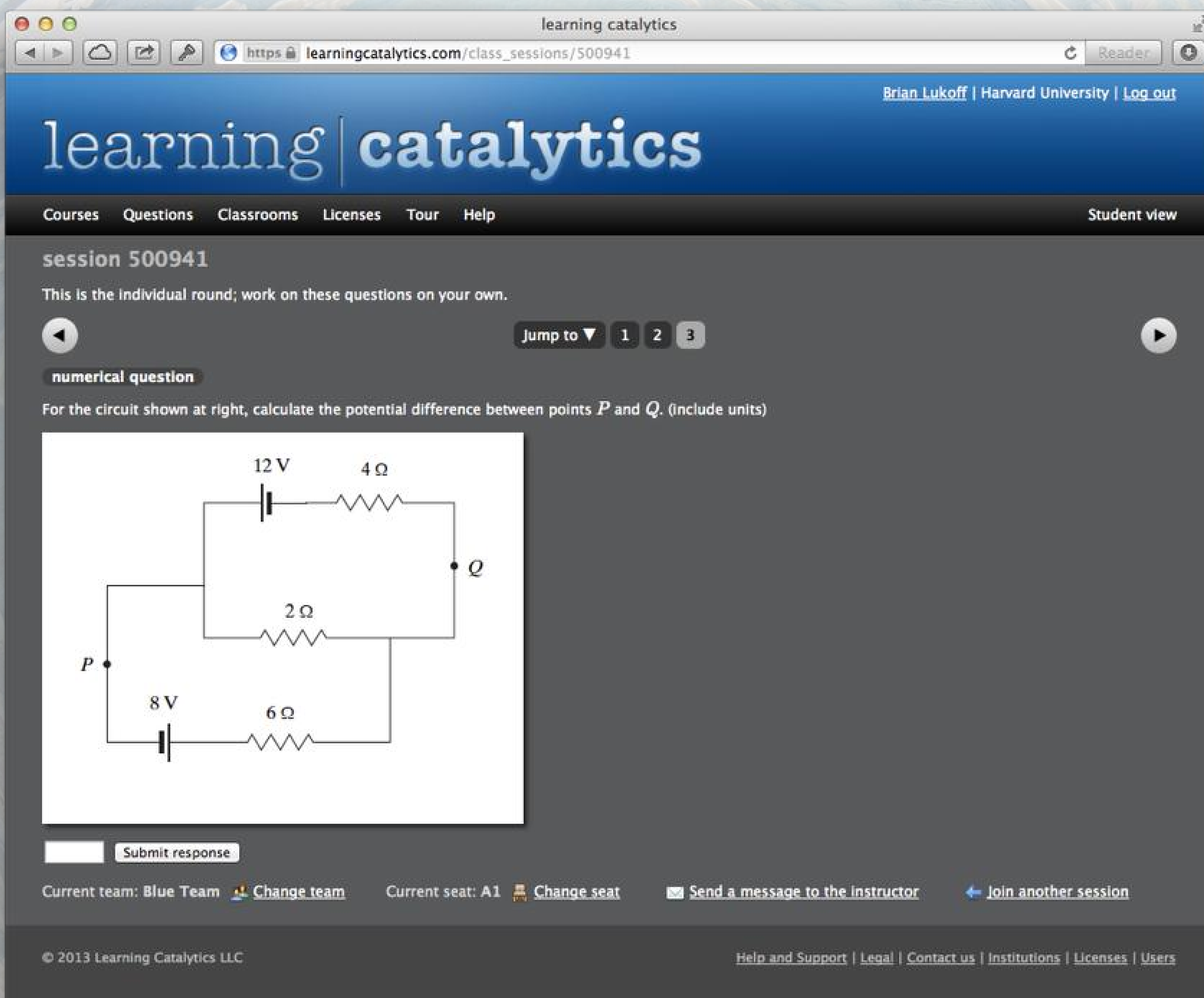
1 design

2 approach

goal: formative assessment

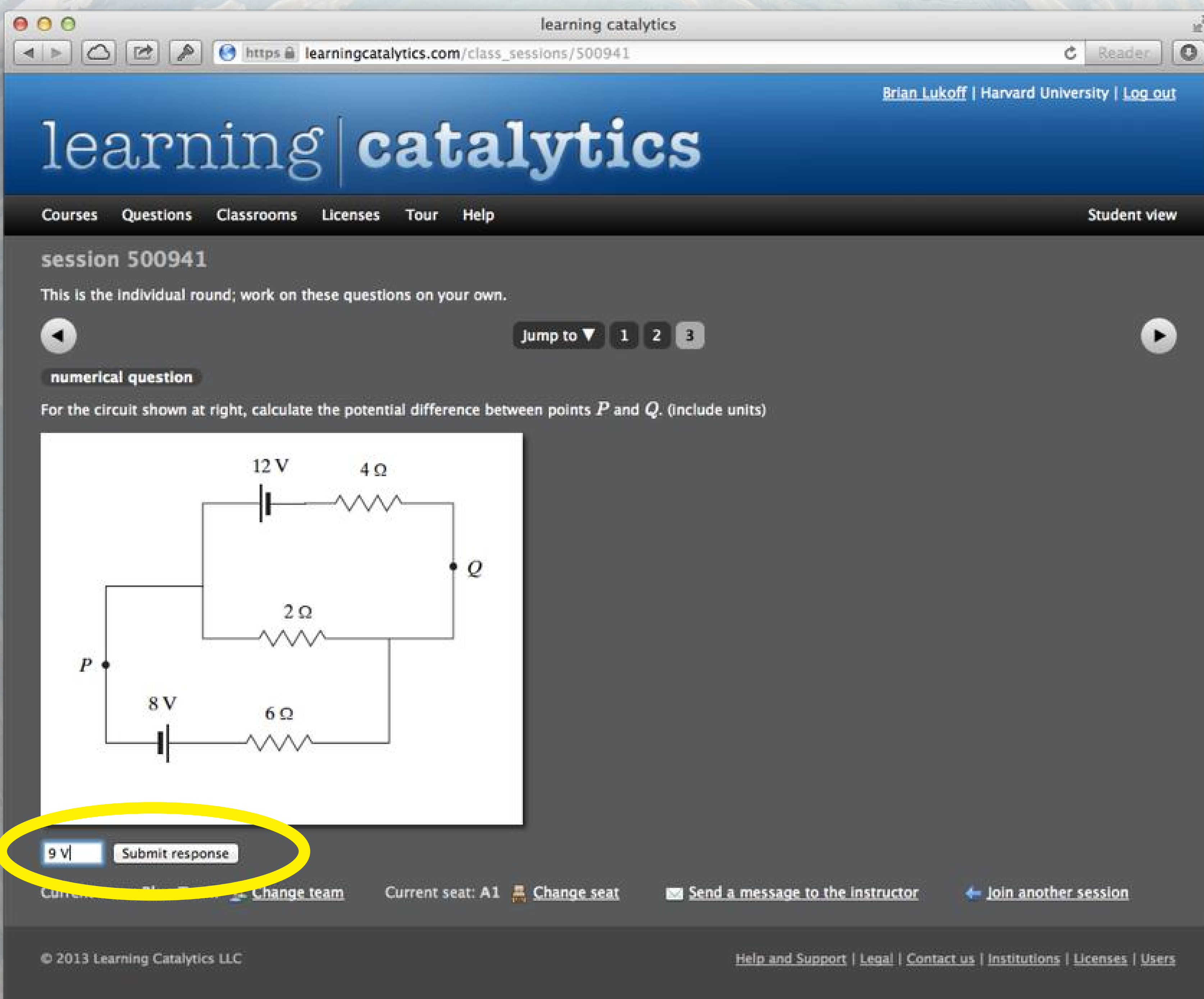
collaborative learning

readiness assurance activity

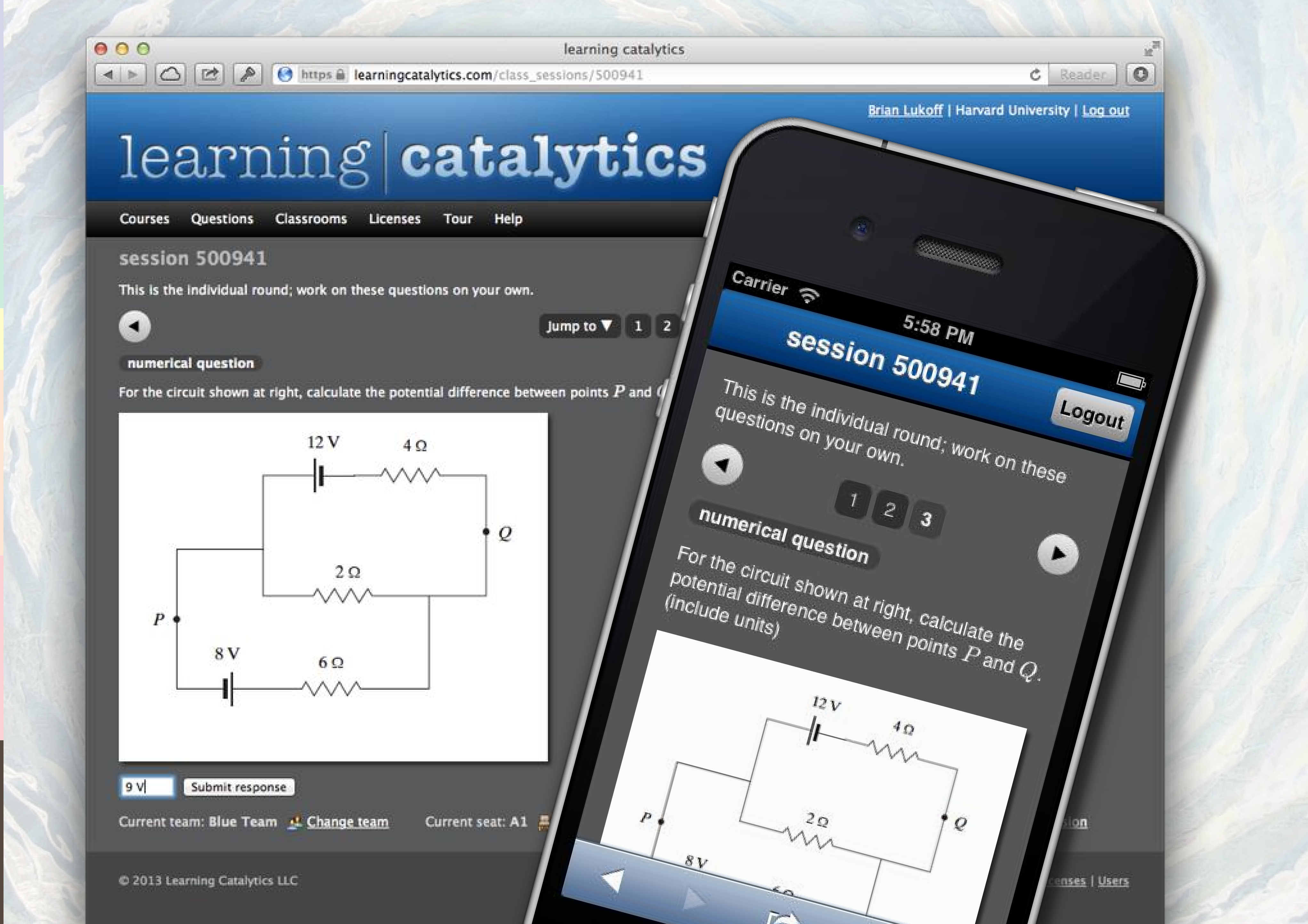


1 design

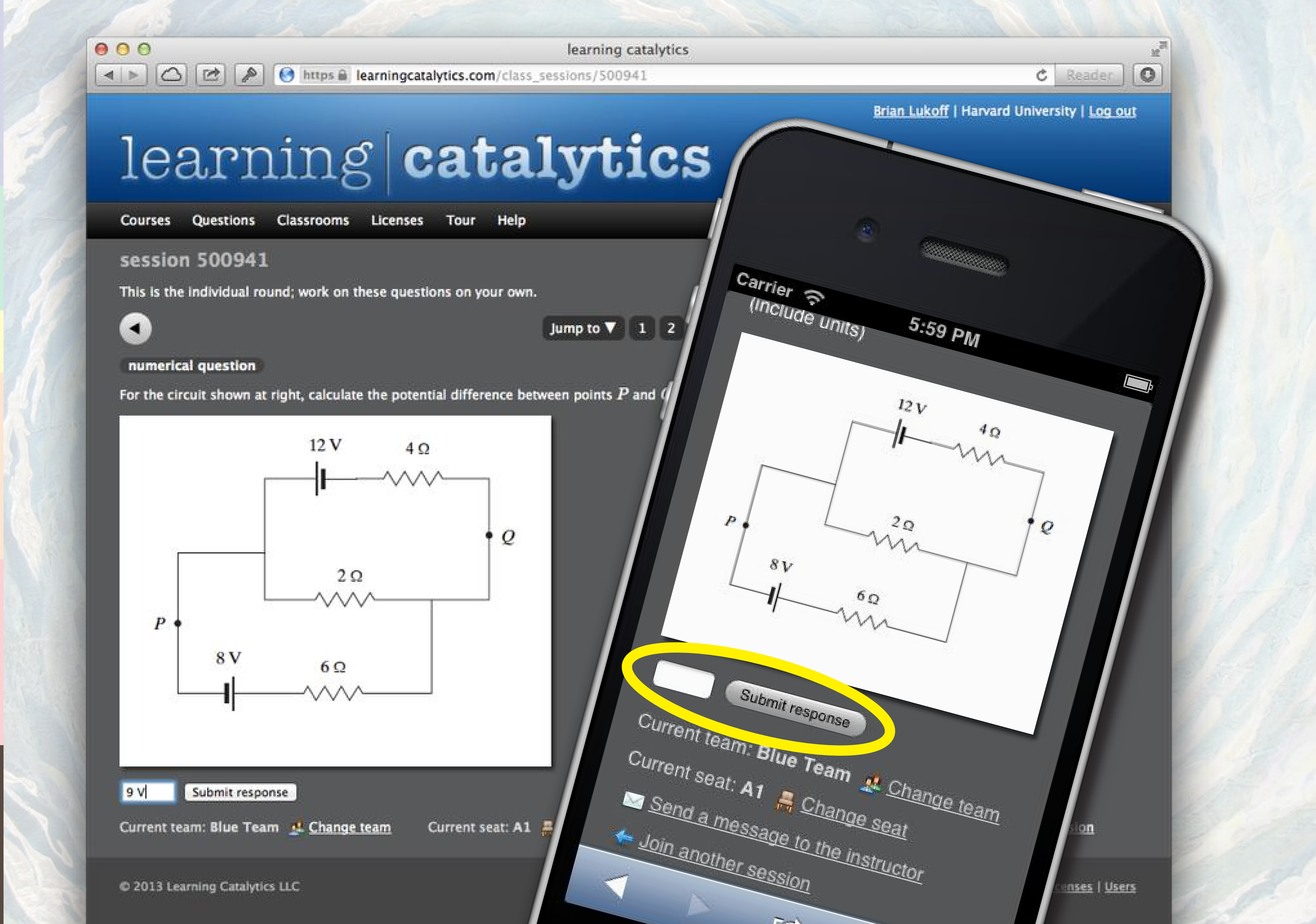
2 approach



1 design 2 approach



❶ **design** ❷ **approach**



1 design 2 approach

learning catalytics

https learningcatalytics.com/class_sessions/500941

Brian Lukoff | Harvard University | Log out

learning | catalytics

Courses Questions Classrooms Licenses Tour Help Student view

session 500941

This is the team round. If you respond to a question, it will count for your entire team (you, Kieran Jones, and Beth Connors). Only one member of your team should respond to each question (otherwise it will count as multiple attempts).

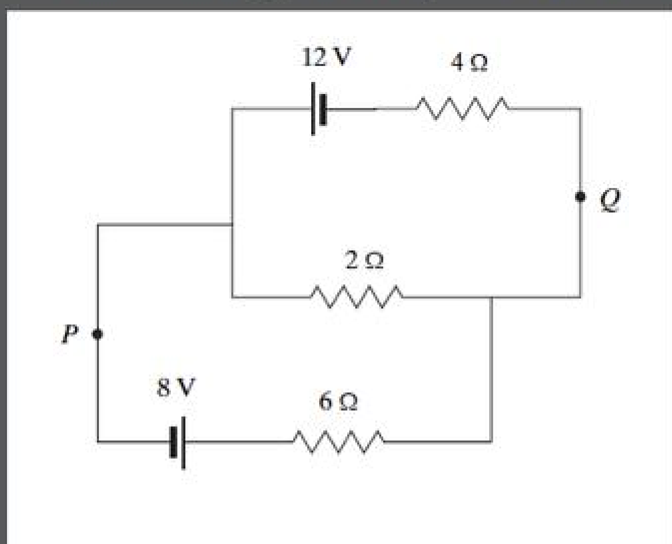
Jump to 1 2 3

Show my team's responses

9 V	1.82 V	1.816 V
Brian Lukoff	Kieran Jones	Beth Connors

numerical question

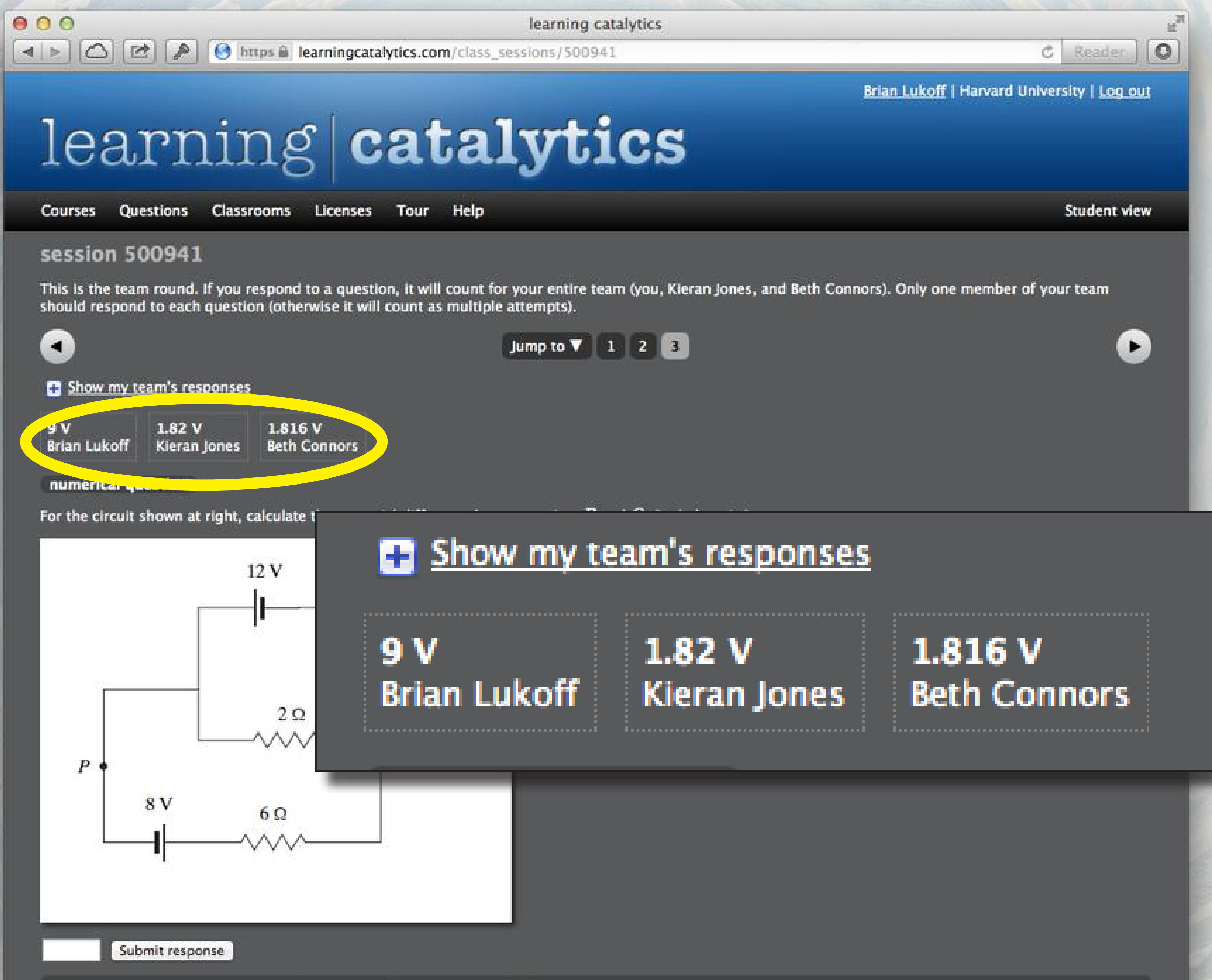
For the circuit shown at right, calculate the potential difference between points P and Q. (include units)



Submit response

1 design

2 approach

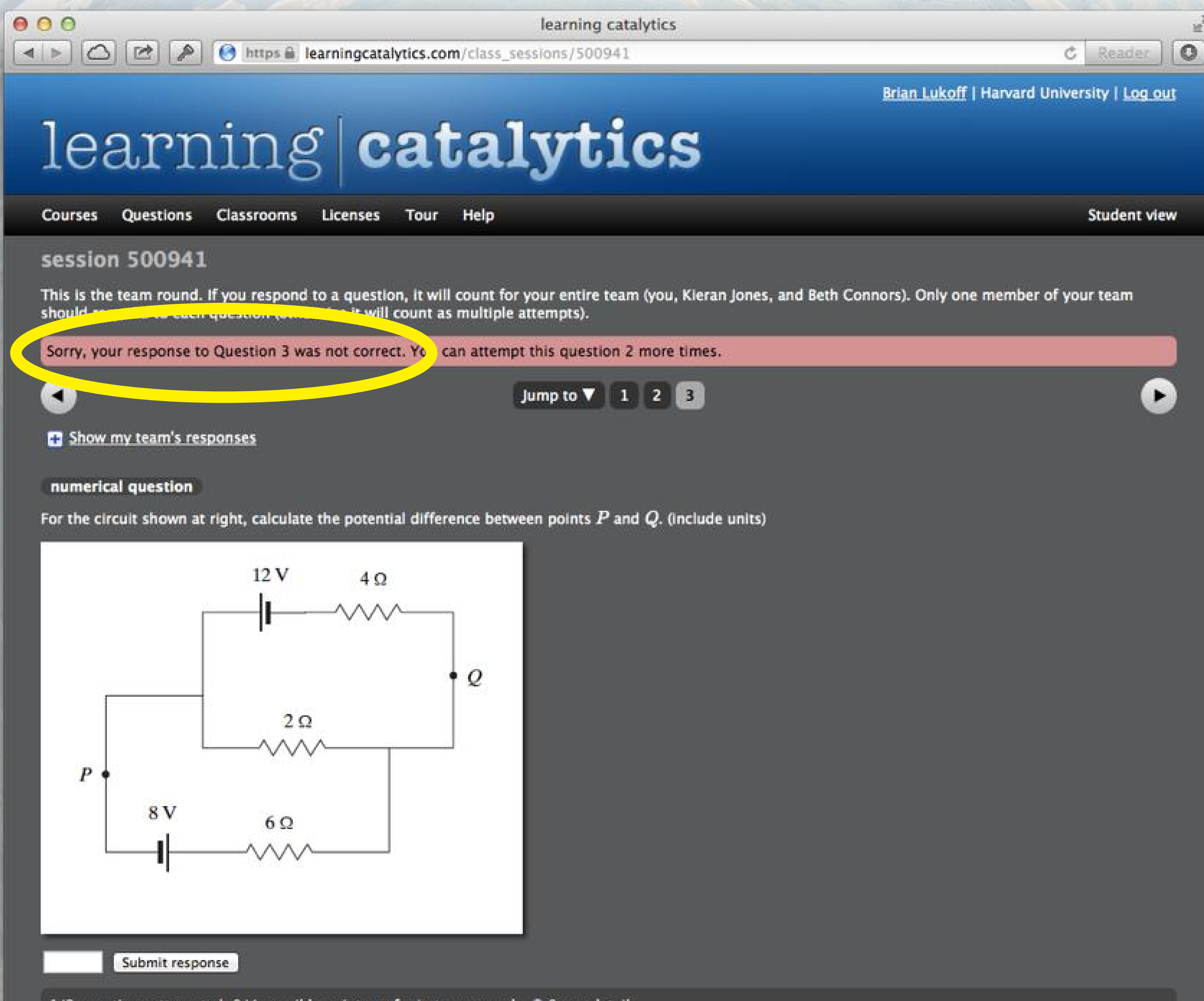


1 design

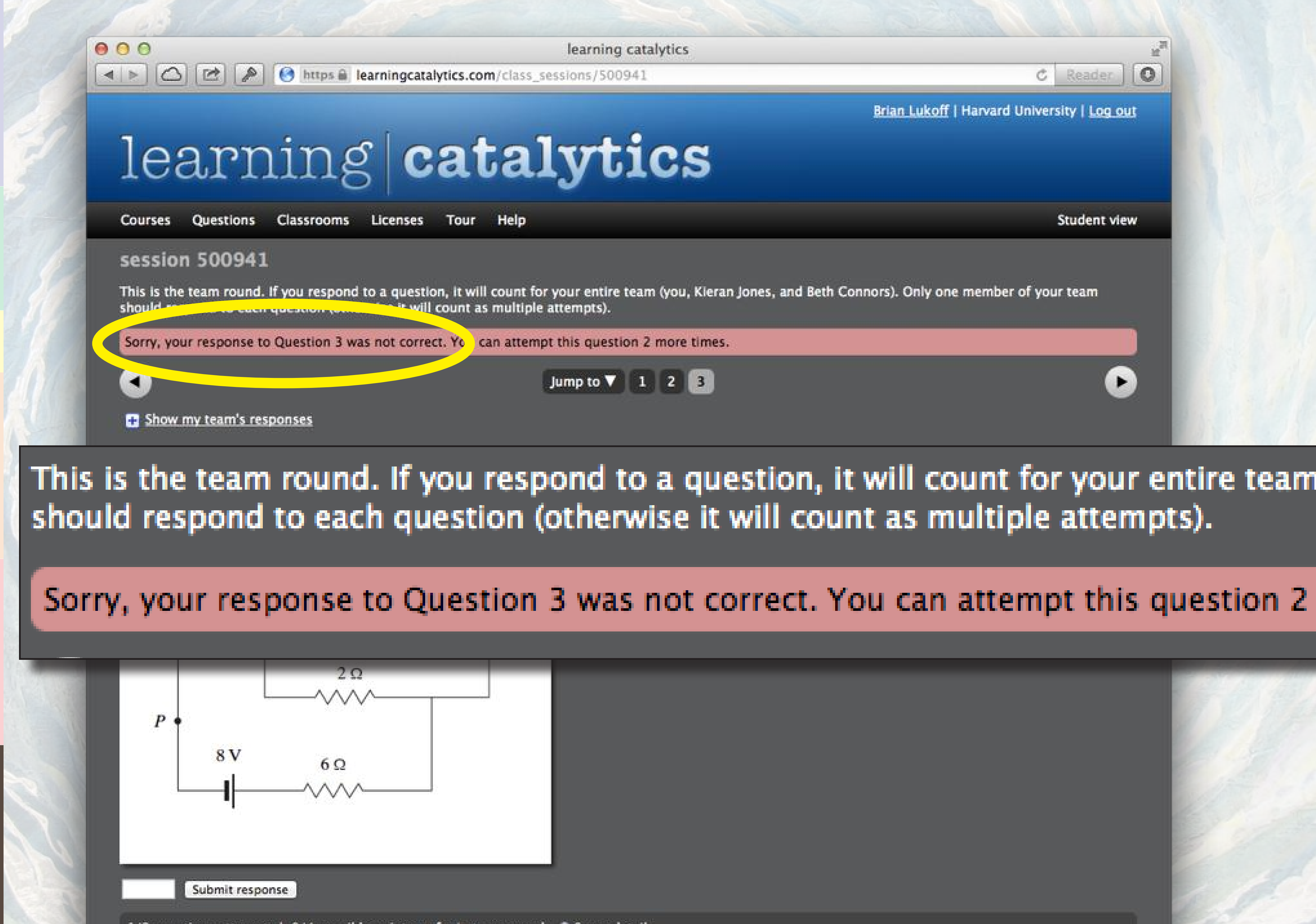
2 approach

1 design

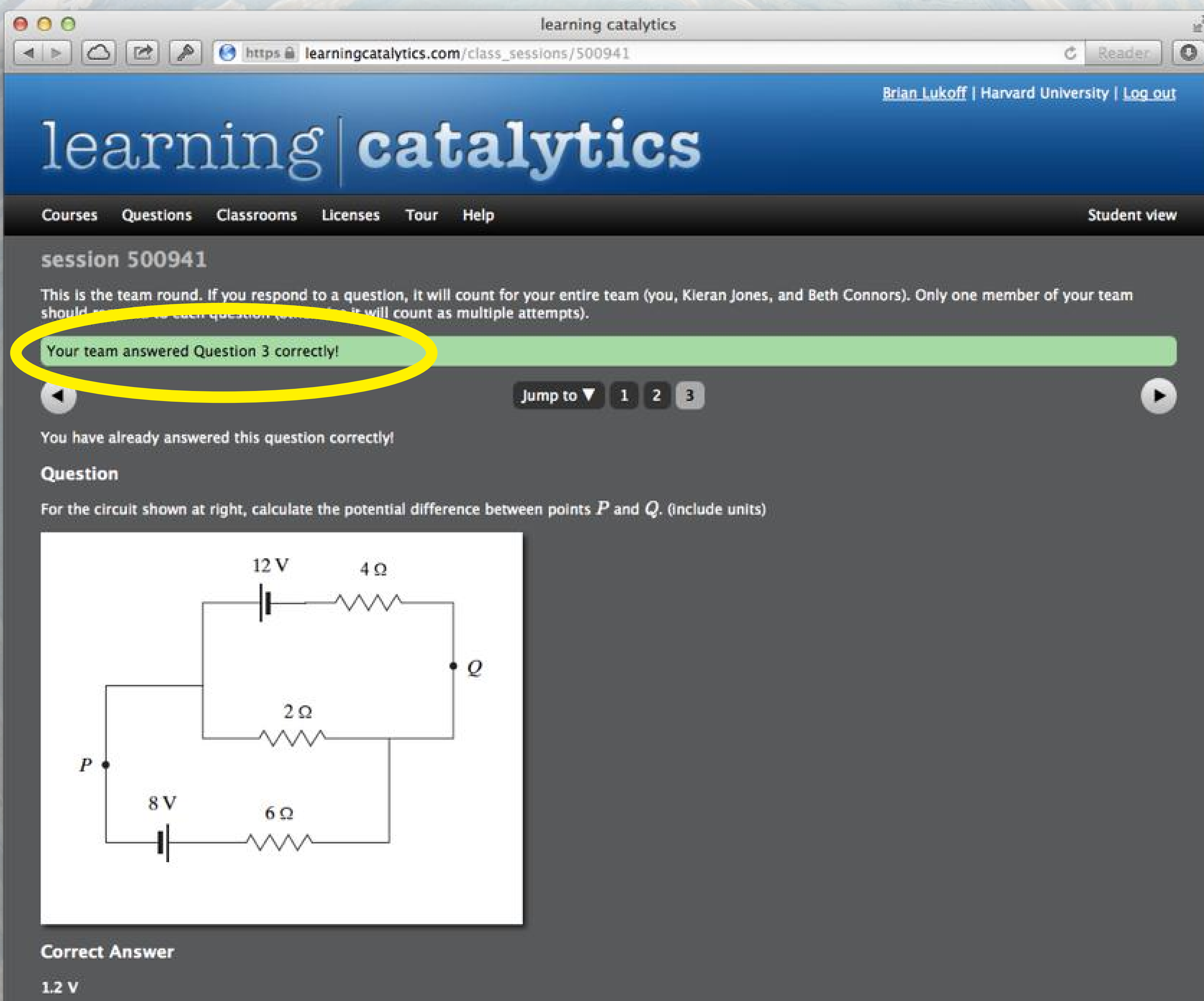
2 approach



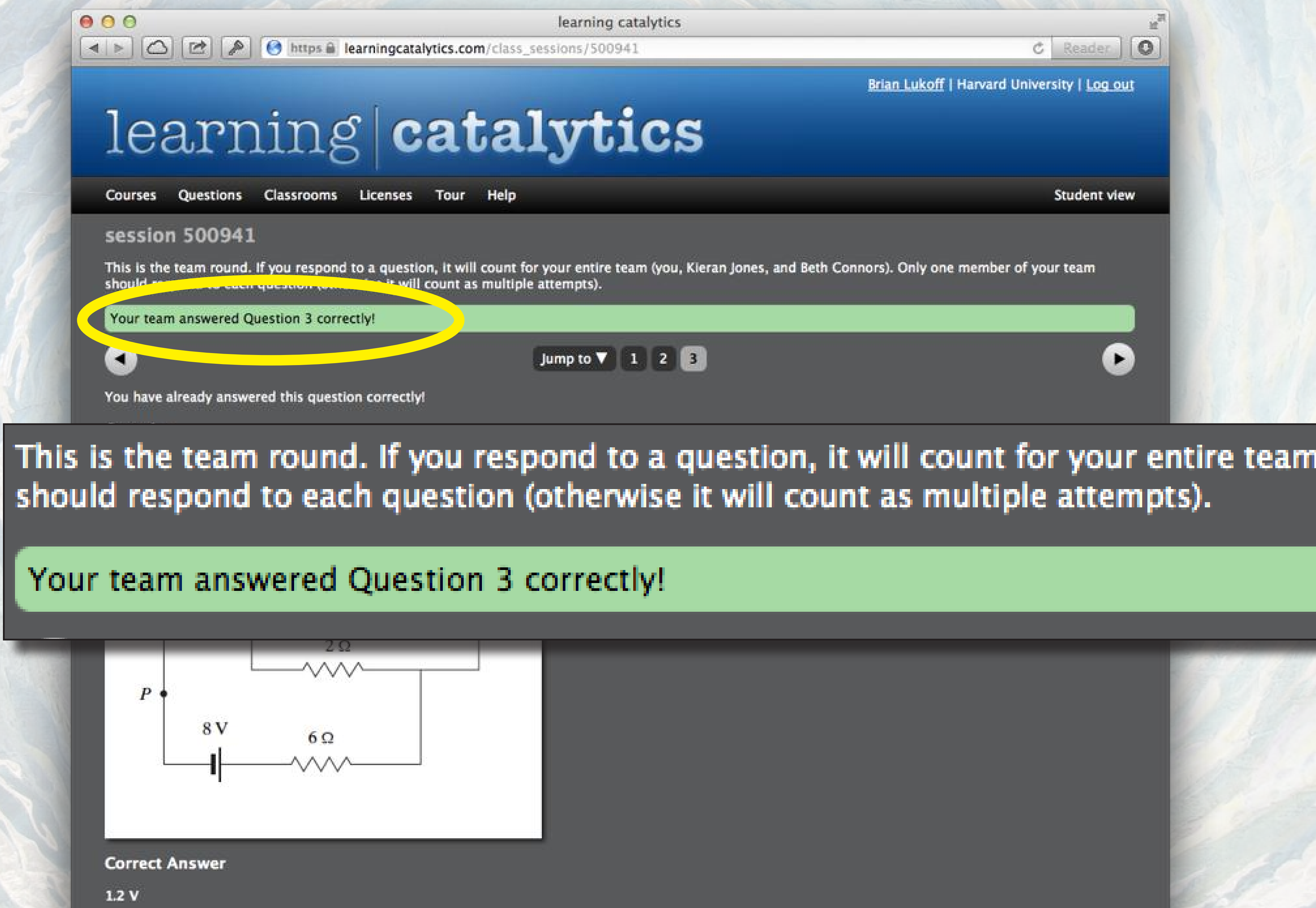
1 design 2 approach



1 design 2 approach



1 design 2 approach



1 design 2 approach

session 500941

This is the team round. If you respond to a question, it will count for your entire team (you, Kieran Jones, and Beth Connors). Only one member of your team should respond to each question (otherwise it will count as multiple attempts).

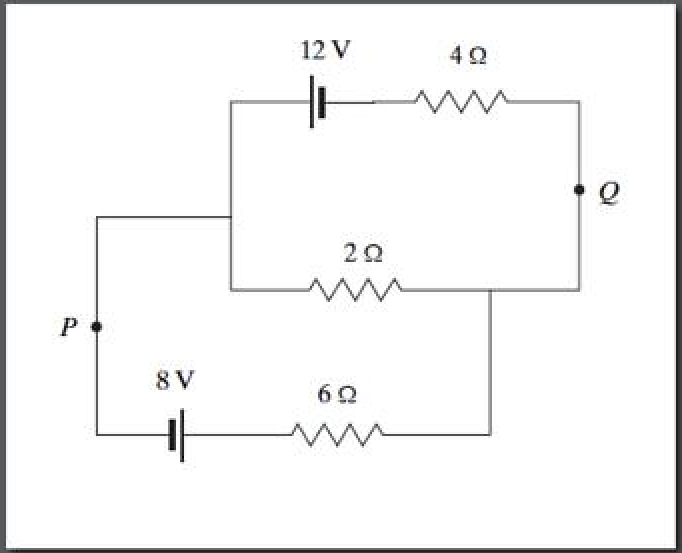
Your team answered Question 3 correctly!

Jump to ▼ 1 2 3

You have already answered this question correctly!

Question

For the circuit shown at right, calculate the potential difference between points P and Q. (include units)



Correct Answer

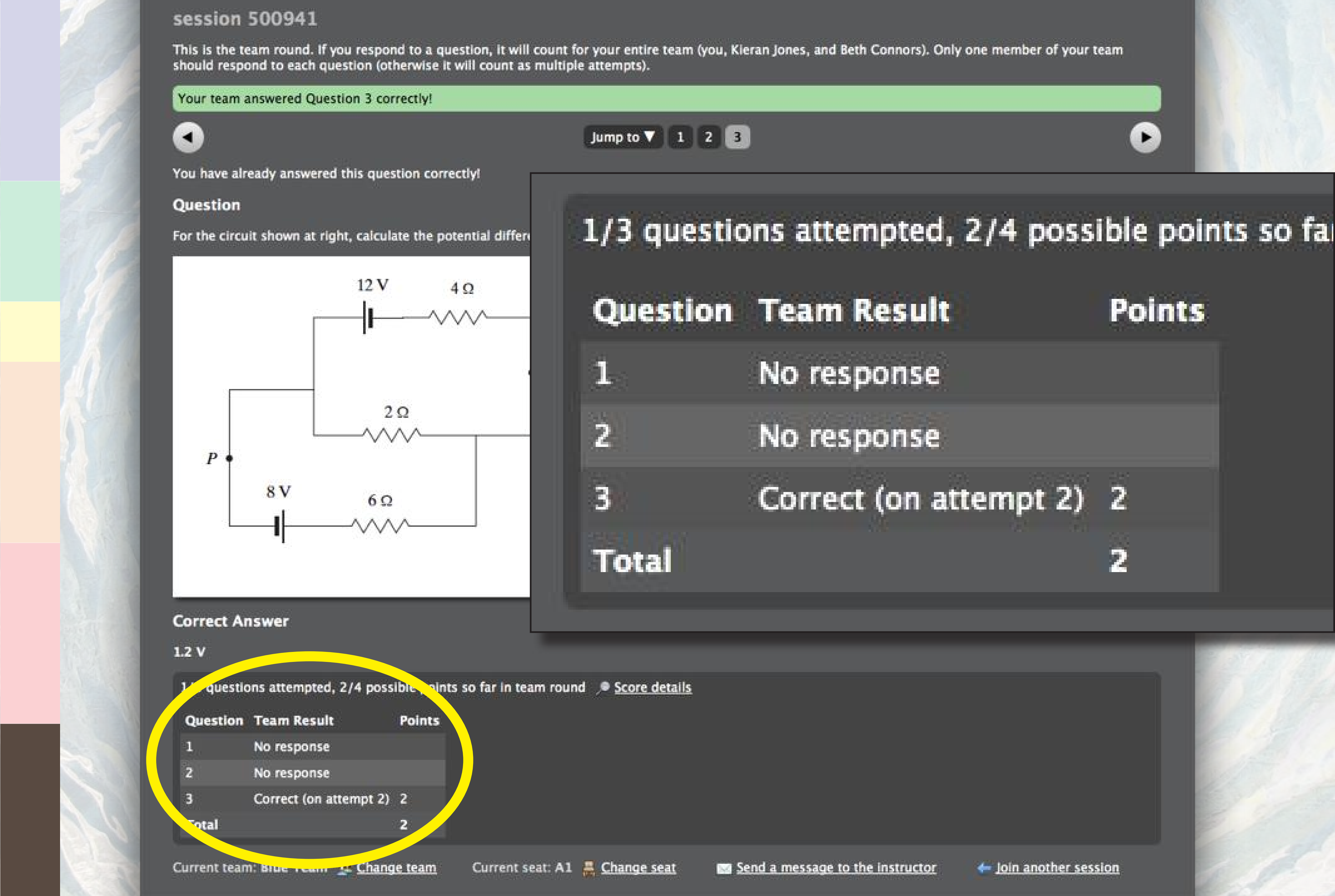
1.2 V

1/3 questions attempted, 2/4 possible points so far in team round Score details

Question	Team Result	Points
1	No response	
2	No response	
3	Correct (on attempt 2)	2
Total		2

Current team: Blue Team Change team Current seat: A1 Change seat Send a message to the instructor Join another session

1 design **2 approach**

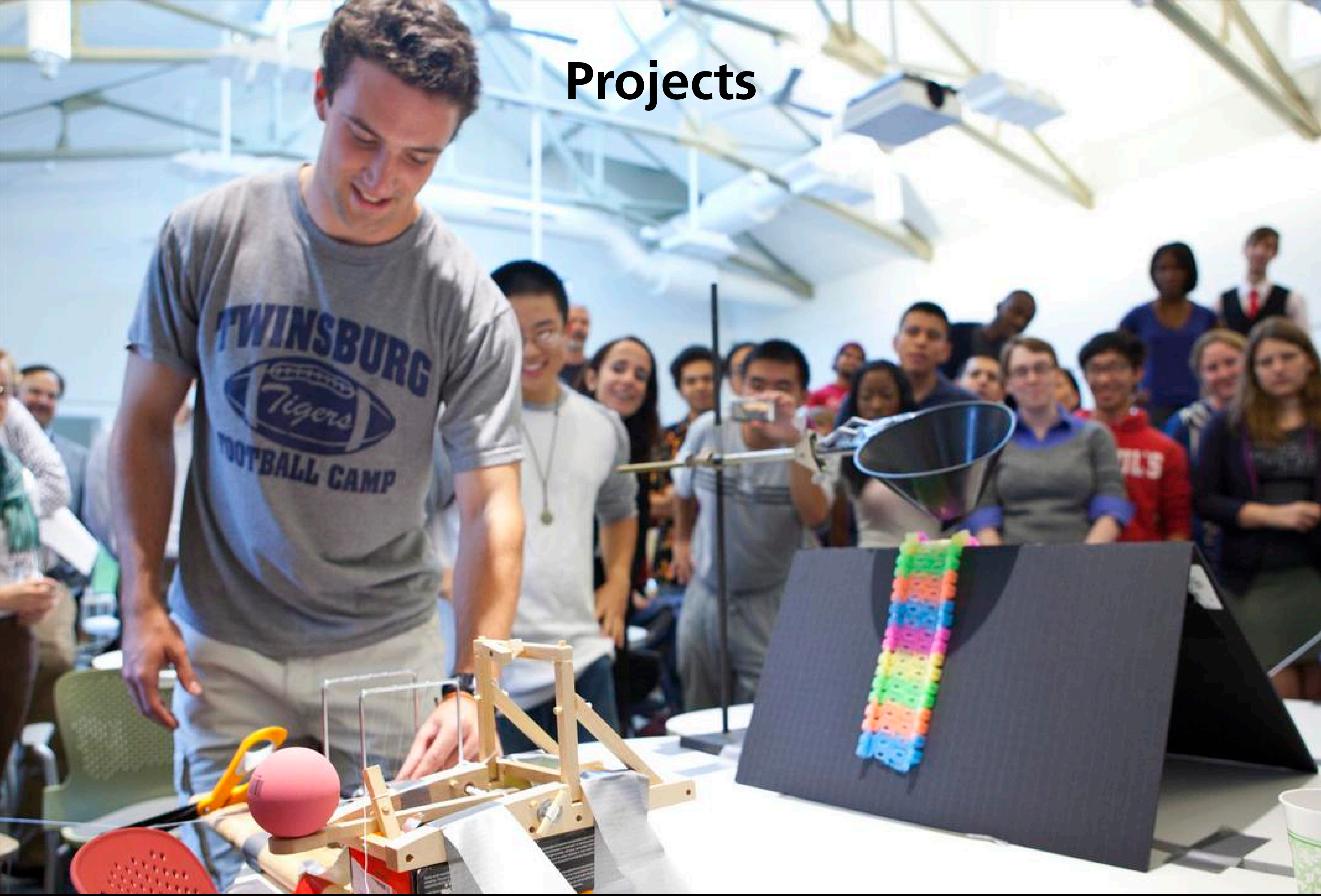


1 design 2 approach

1 design

2 approach

Projects



1. design
2. approach

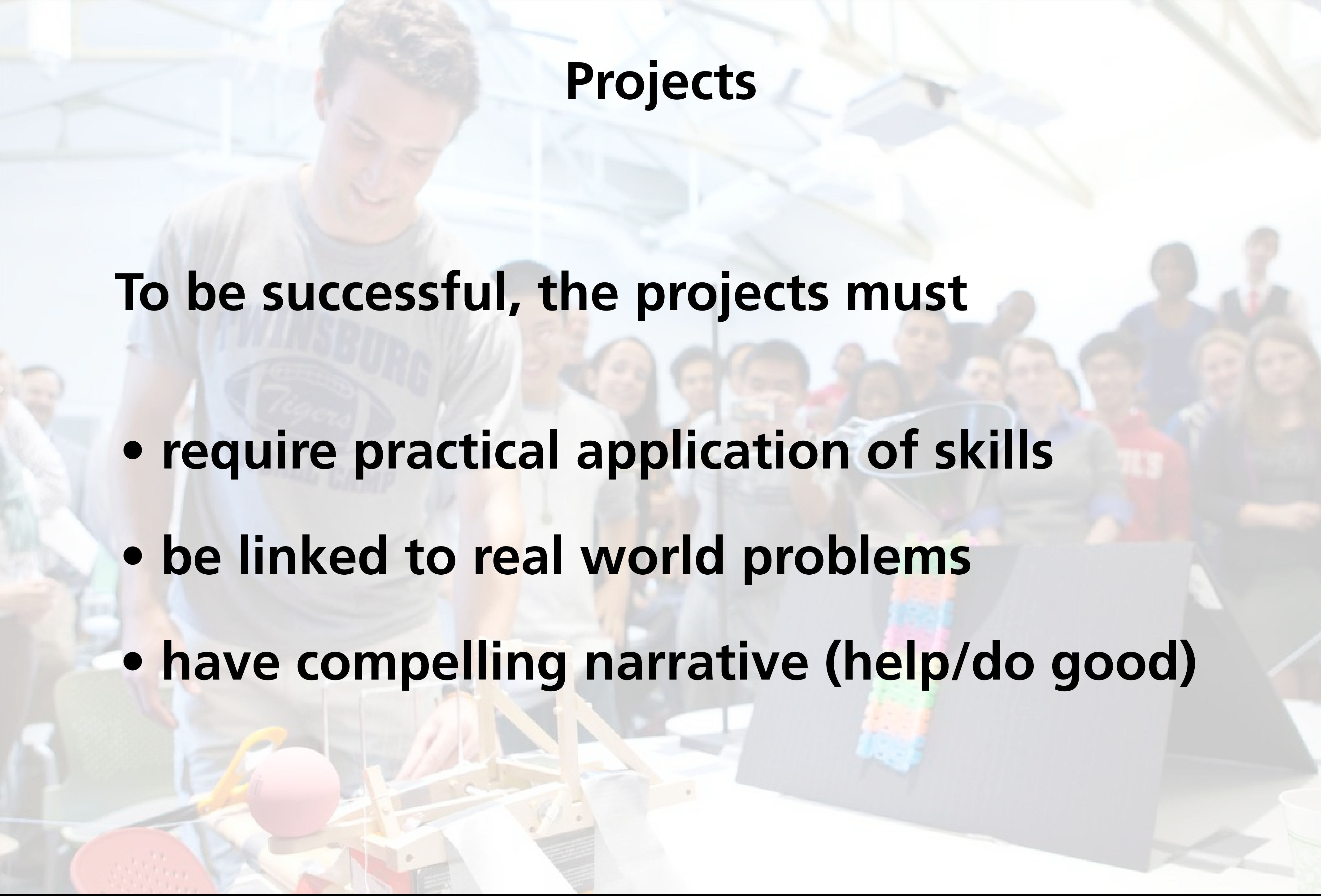
Projects

- 3 projects/semester
- each project roughly one month long
- different team formation for each project
- projects not prescriptive, but open-ended
- 3 types of project “fairs”

Projects

Project fair types:

- design competition
- oral presentation
- poster presentation



Projects

To be successful, the projects must

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

Wee

Week

Week 3

Week 4

1 design

CRACK-A-THON

AP50

Wed Apr 10 • 2–5 pm • Pierce 301

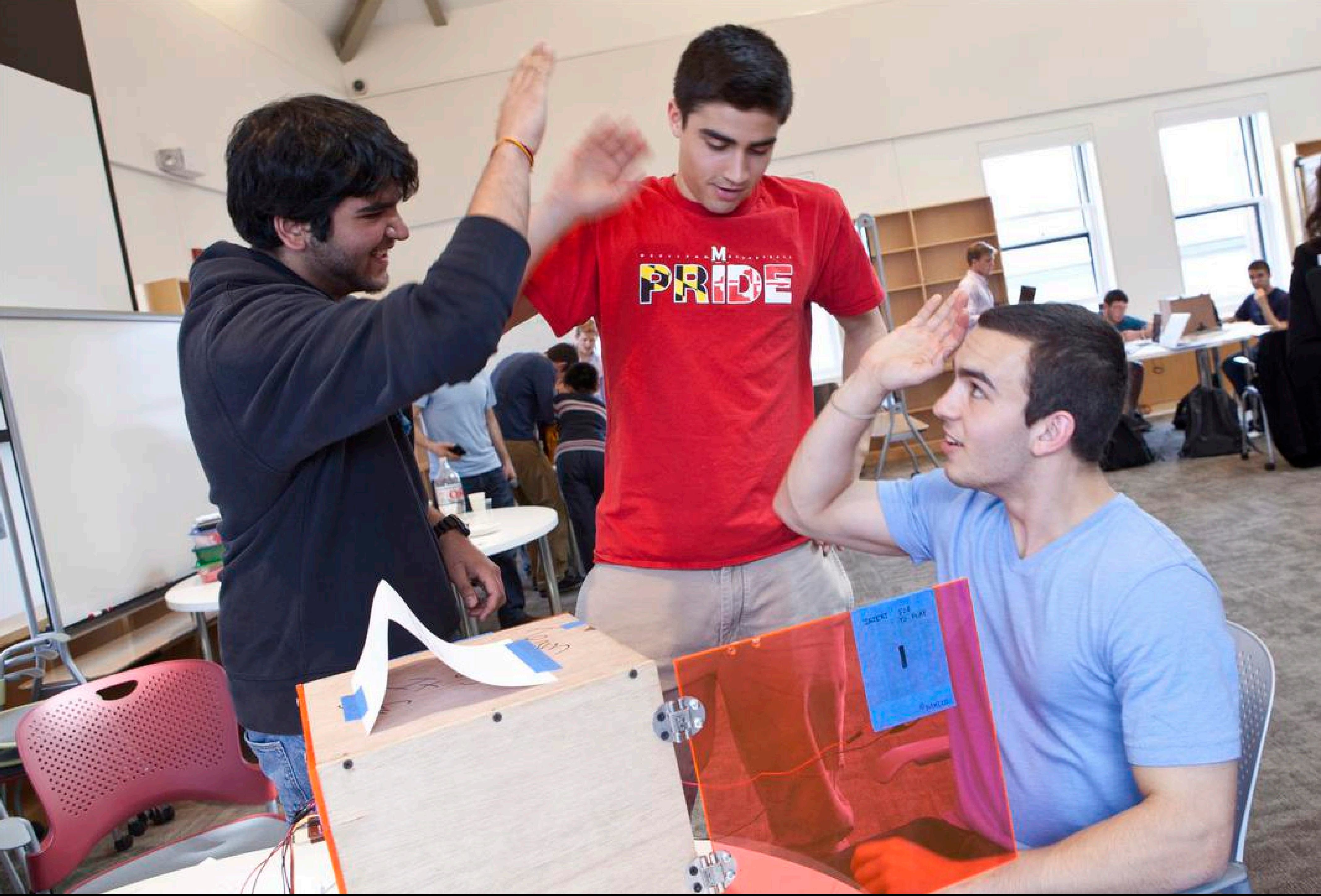
1 design

2 approach

1 design **2** approach

1 design

2 approach



1 design 2 approach

AP50b Fall 2013

Peer Assessment

Team work is central in your projects and it is important to provide positive feedback to people who truly worked hard for the good of the team and to also make suggestions to those you perceived not to be working as effectively on team tasks. You may want to review the sections entitled on Teamwork and Peer Assessment in the syllabus to refresh your memory on why we stress teamwork and how to maximize the benefit from work together. Please complete the form below to assess your own contributions and those of your team members.

Complete the paper based form, then enter the data online at: http://bit.ly/AP50Teameval

How we will use your evaluation: In computing the (multiplicative) weight we give to your team scores, we will take into account:

1. Your team members' assessment of your contributions,
2. the quality of your self assessment (that is, how well it matches that of your team members' evaluation of your contribution), and
3. the quality of your assessment of your team members (that is, how well it matches the evaluations of that team member's contribution by the remainder of the team).

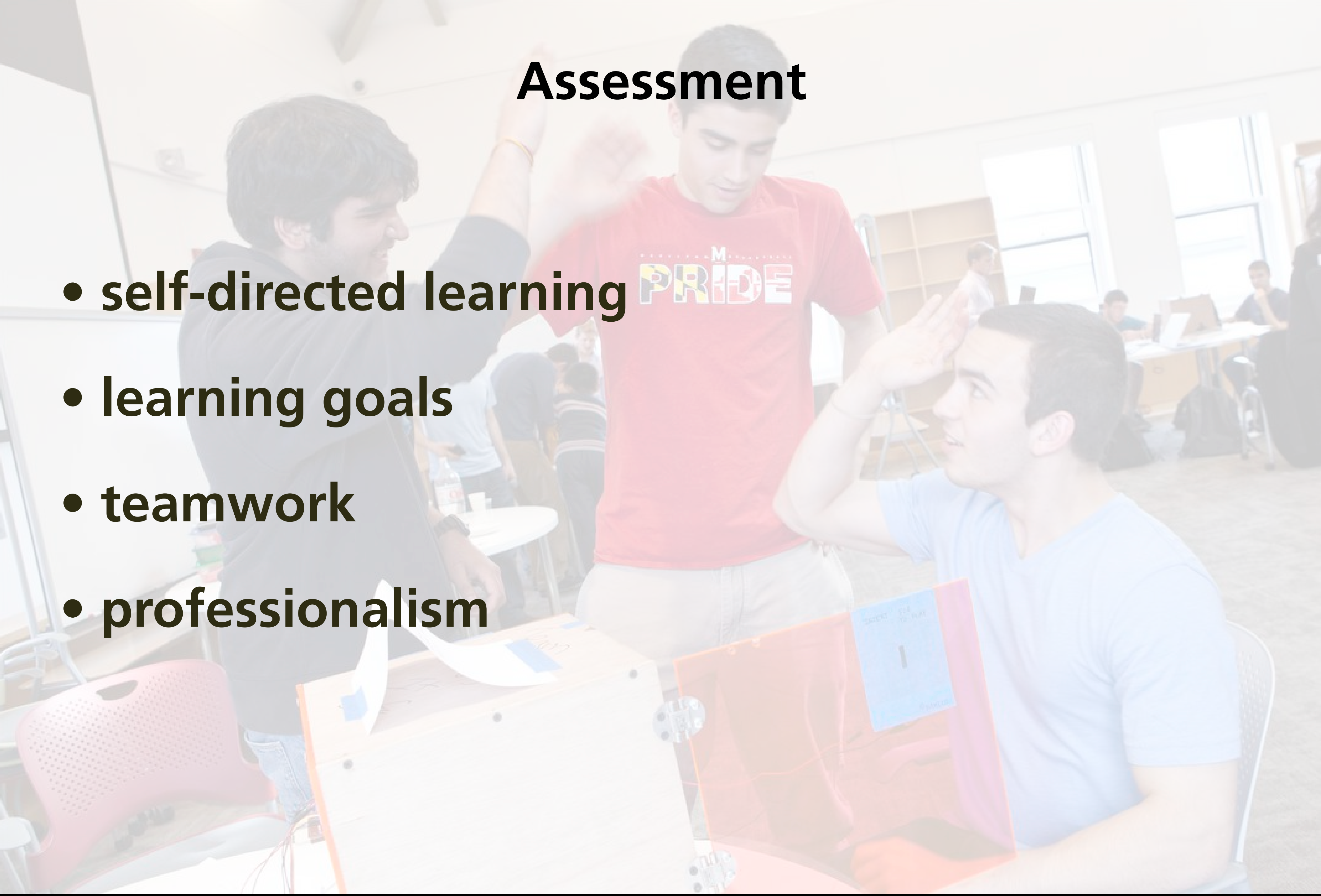
Please first complete the individual forms for each team member (including yourself), then complete the table below. When completing the table below, be sure that the **total of all relative contributions must be zero**.

		RELATIVE CONTRIBUTION Total must equal **ZERO**						
		Below Average			Average	Above average		
	Name	−3	−2	−1	0	1	2	3
Me								
Member 1								
Member 2								
Member 3								
Member 4								

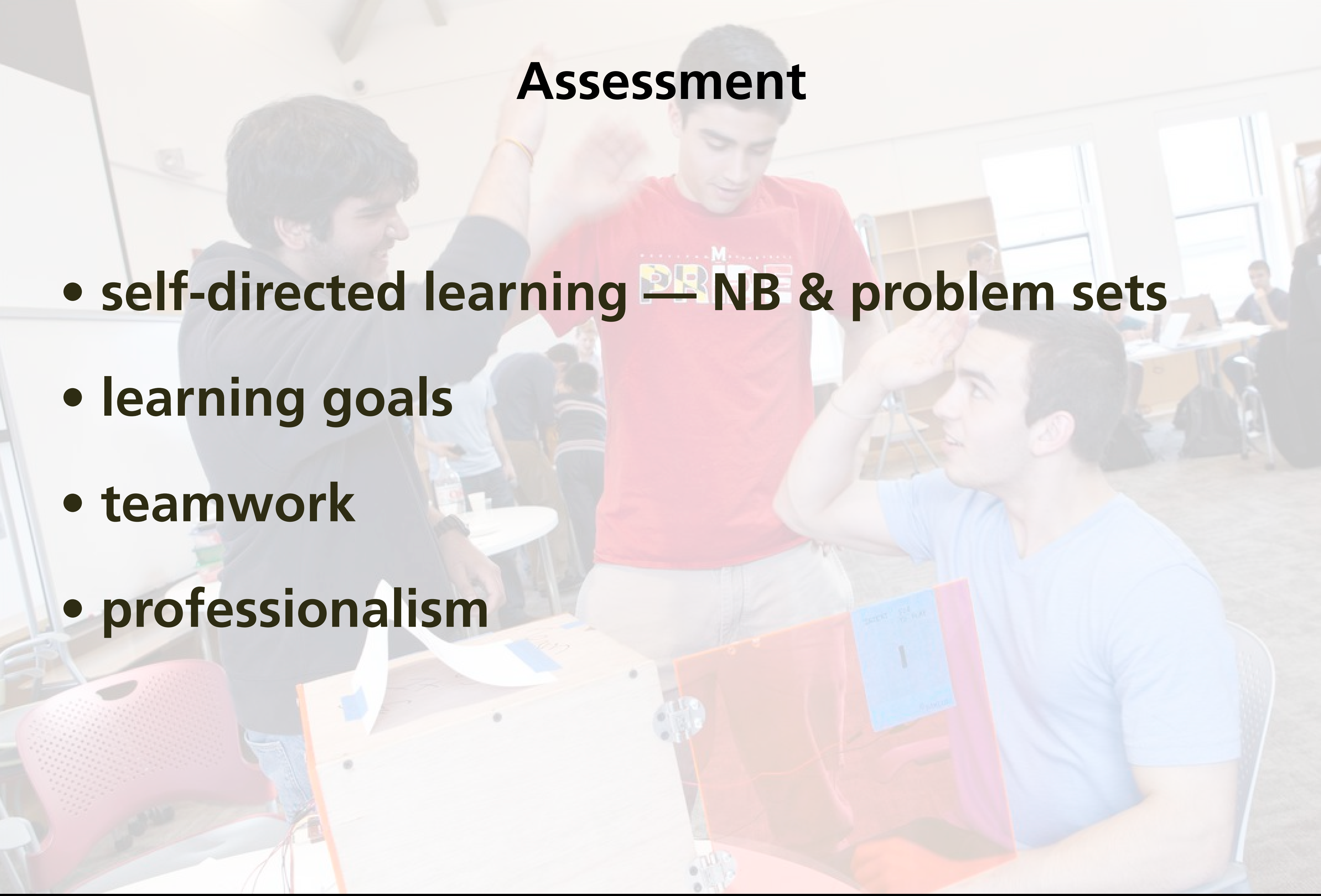
1 design

2 approach

Assessment

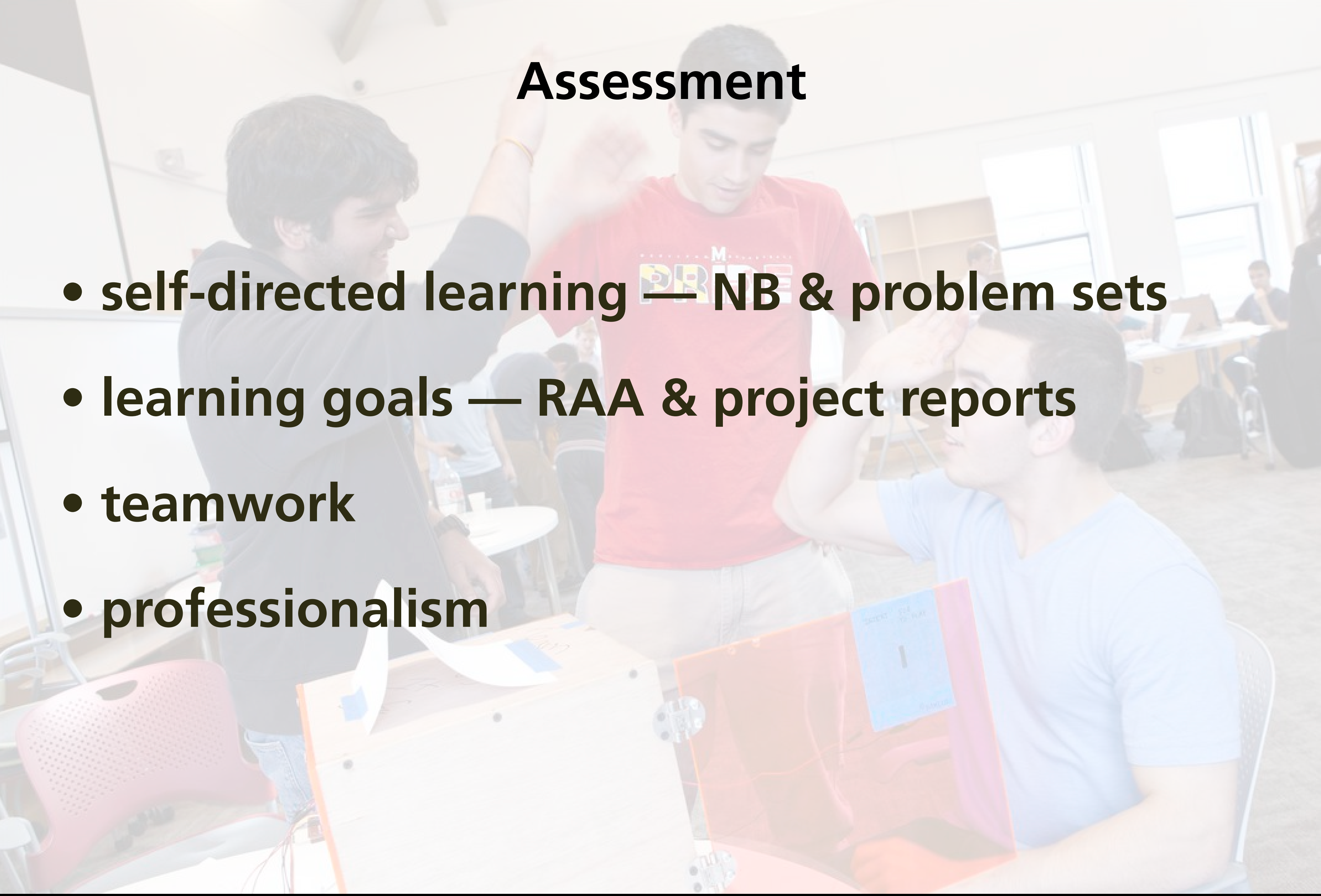


- self-directed learning
- learning goals
- teamwork
- professionalism



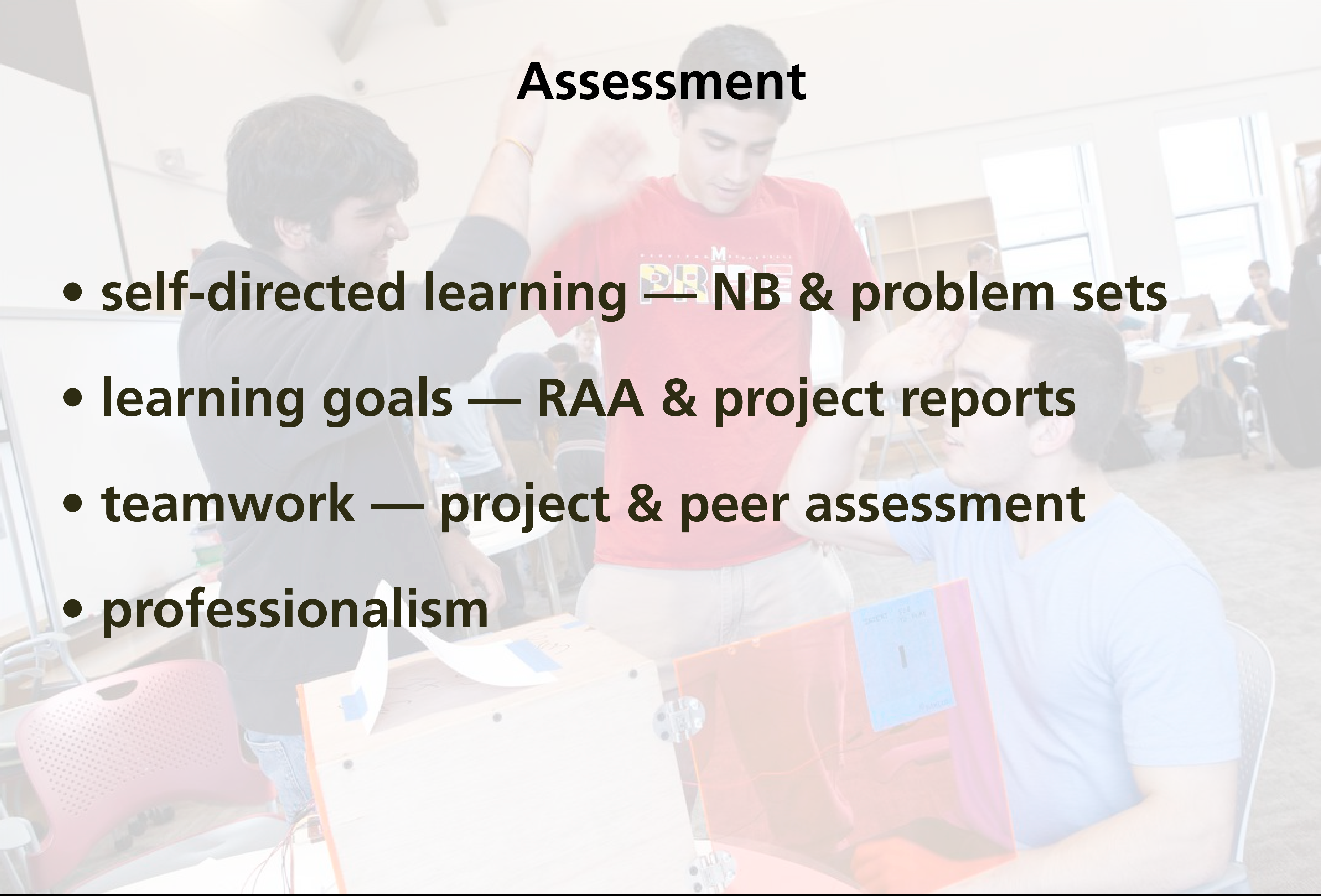
Assessment

- self-directed learning — NB & problem sets
- learning goals
- teamwork
- professionalism



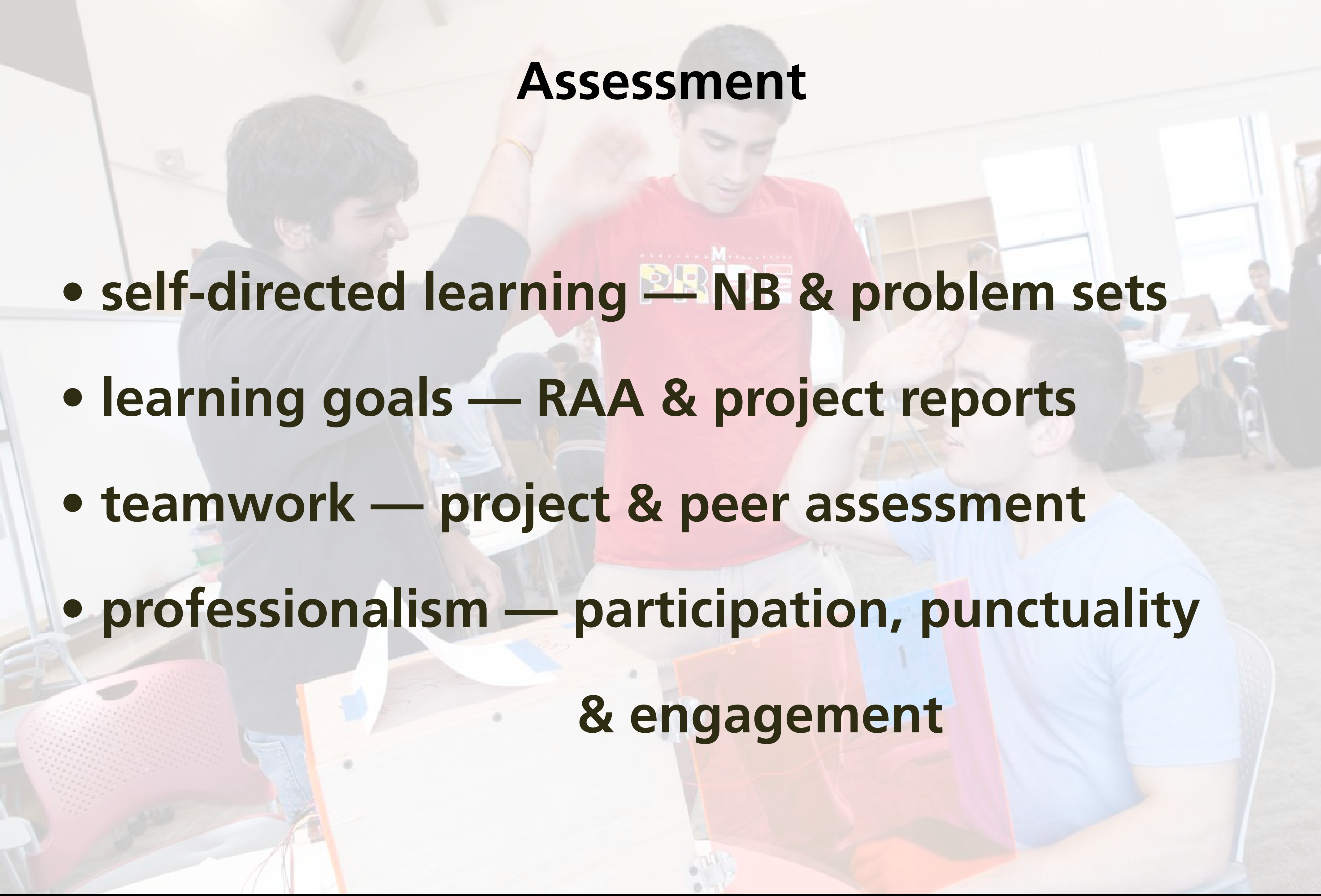
Assessment

- self-directed learning — NB & problem sets
- learning goals — RAA & project reports
- teamwork
- professionalism



Assessment

- self-directed learning — NB & problem sets
- learning goals — RAA & project reports
- teamwork — project & peer assessment
- professionalism



Assessment

- self-directed learning — NB & problem sets
- learning goals — RAA & project reports
- teamwork — project & peer assessment
- professionalism — participation, punctuality

  & engagement

1 design 2 approach 3 results

Ownership

Ownership

Course evaluation: 4.2/5

Ownership

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

Ownership

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

Ownership

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

Ownership

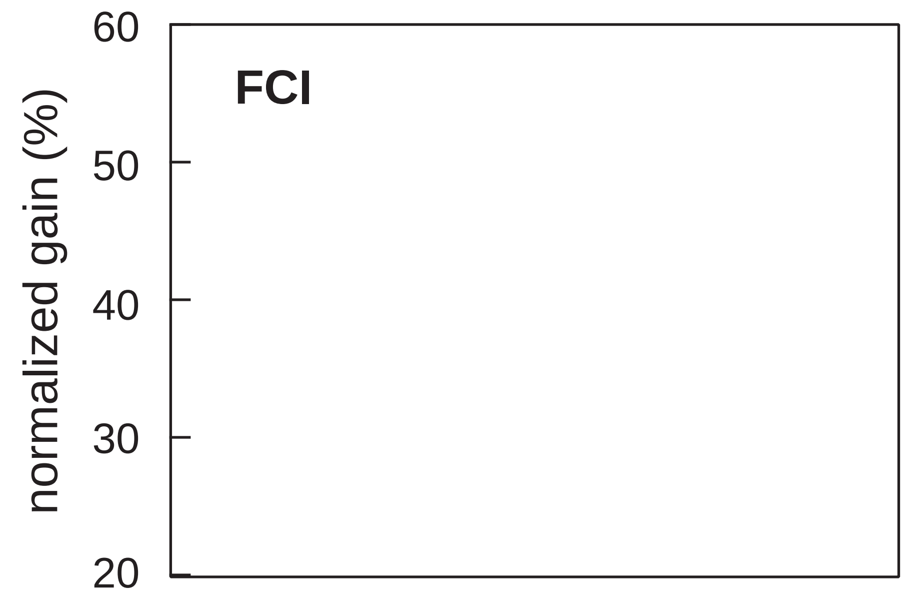
Attendance: 94% (AP50a), 97% (AP50b)

Ownership

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

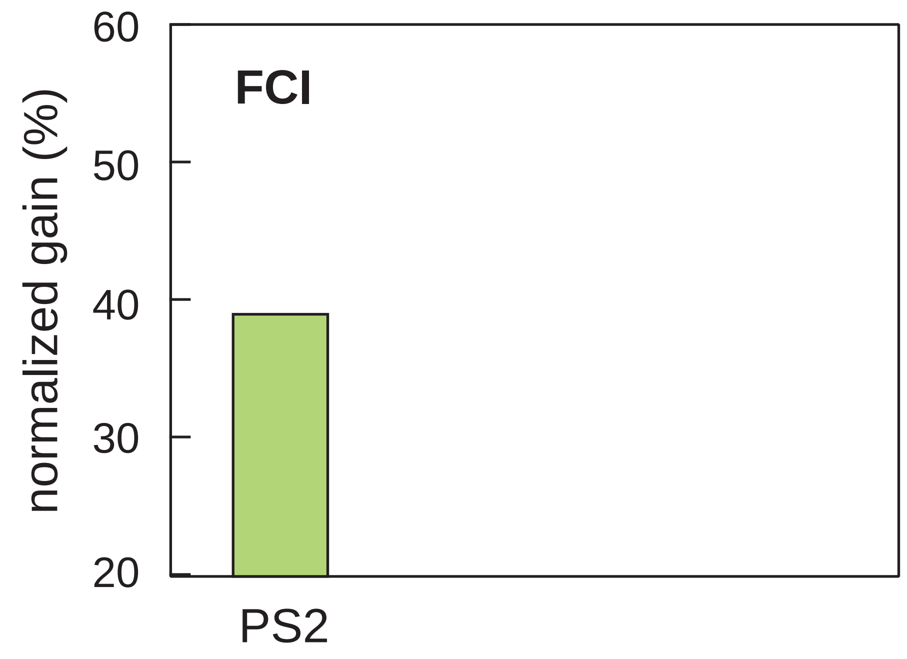
3 hours and they don't *leave*!

Conceptual Mastery



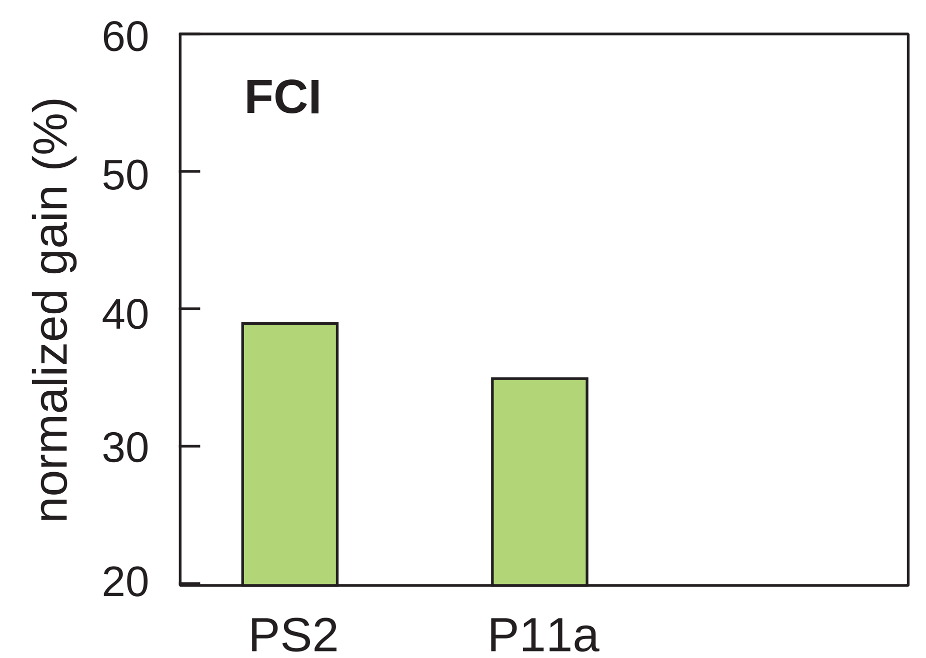
1 design
2 approach
3 results

Conceptual Mastery



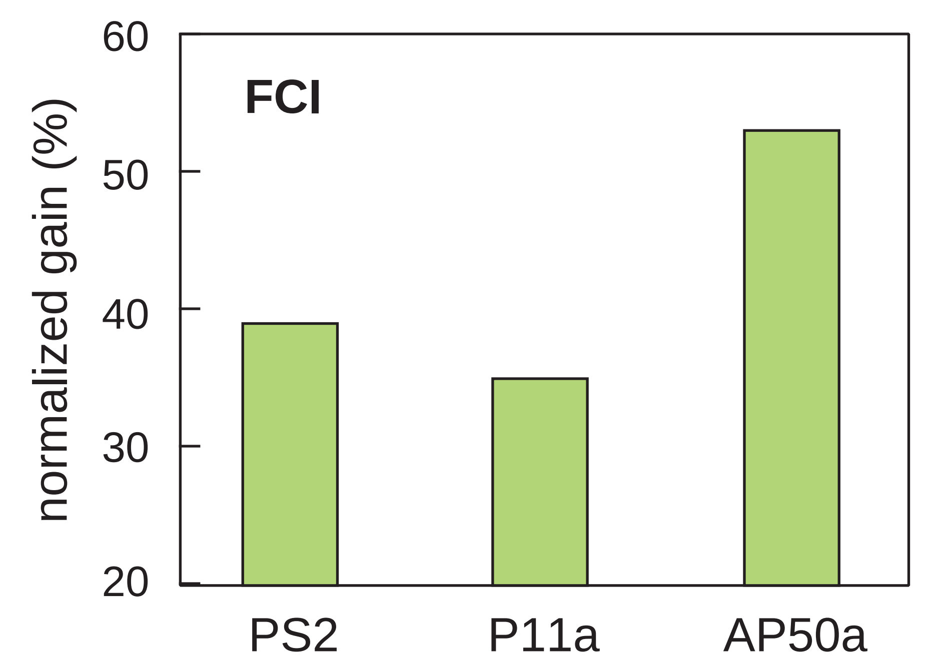
1 design 2 approach 3 results

Conceptual Mastery



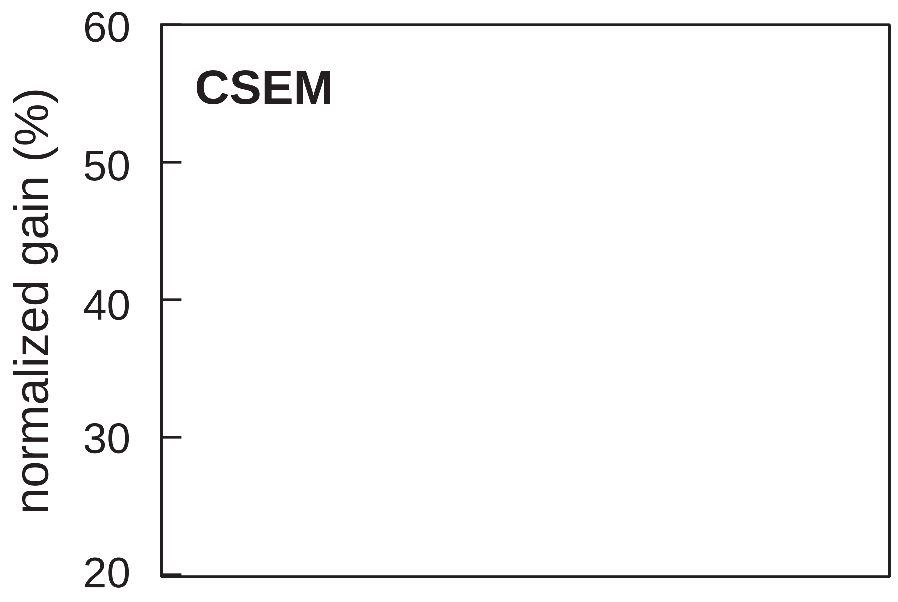
1 design 2 approach 3 results

Conceptual Mastery



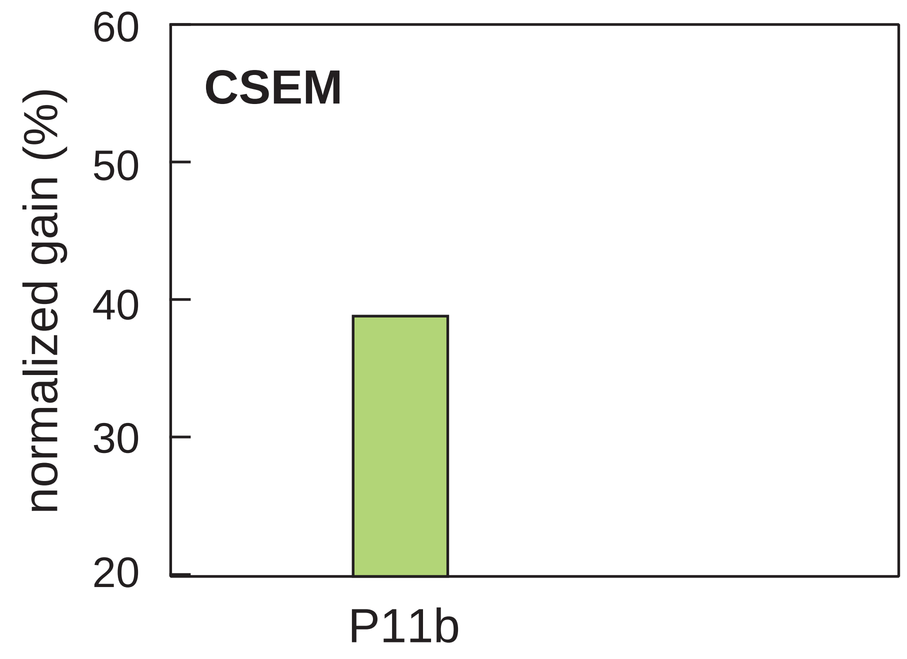
1 design 2 approach 3 results

Conceptual Mastery



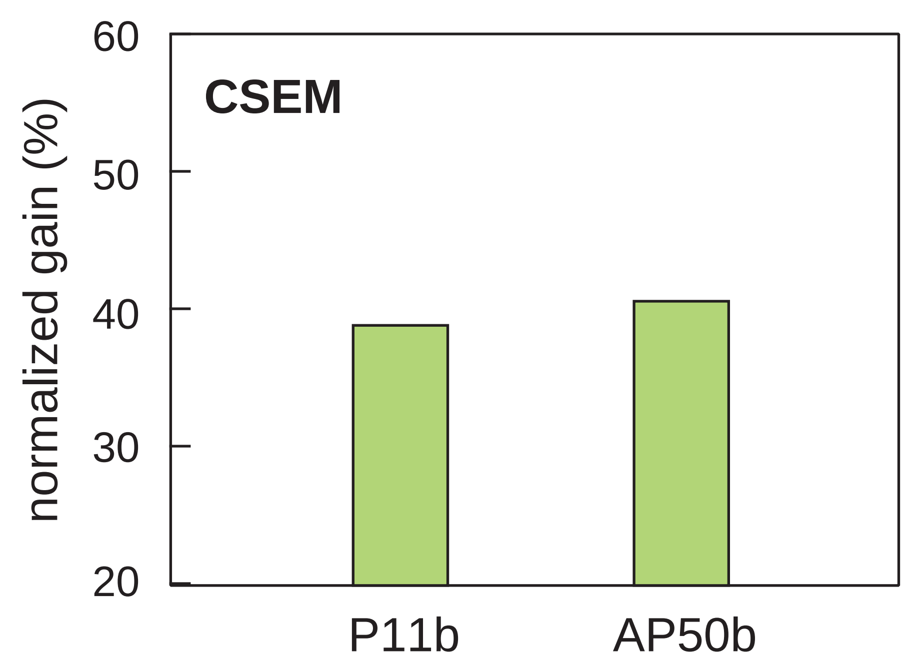
1 design 2 approach 3 results

Conceptual Mastery



1 design
2 approach
3 results

Conceptual Mastery



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"

Support

Cherry Murray

Course planning

Kelly Miller
Orad Reshef

Co-instructor

Carolann Koleci

Teaching staff

Kelly Miller
Orad Reshef
Michael Moebius
Sally Kang

Logistical support

Anas Challah
Peter Kjeer
Jordan Stephens
Wolfgang Rueckner
Nils Sorensen

Education Research

Marcelo Barros
Messias Borges-Silva
Brian Lukoff
Kelly Miller
Alvaro Neves
Julie Schell
Laura Tucker
Fauzy Wan
Junehee Yoo

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Laura Tucker
Fauzy Wan
Junehee Yoo

and the students pioneers in AP50!

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mazur.harvard.edu

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