Flat space, deep learning

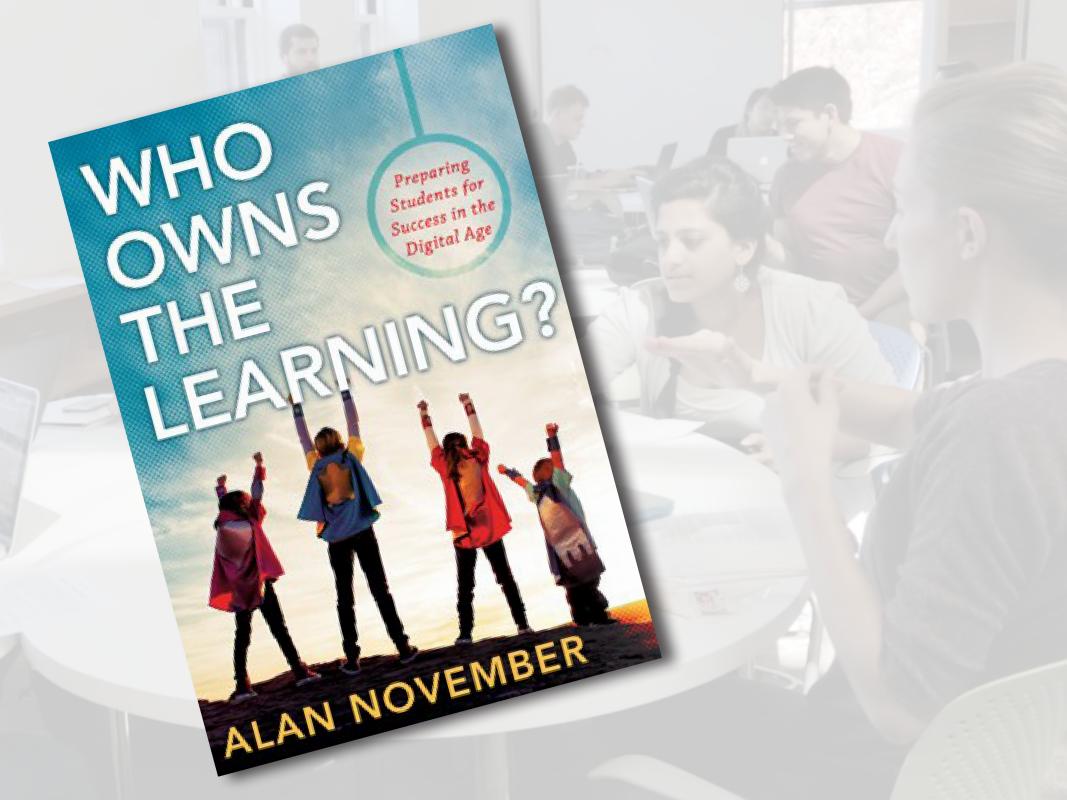


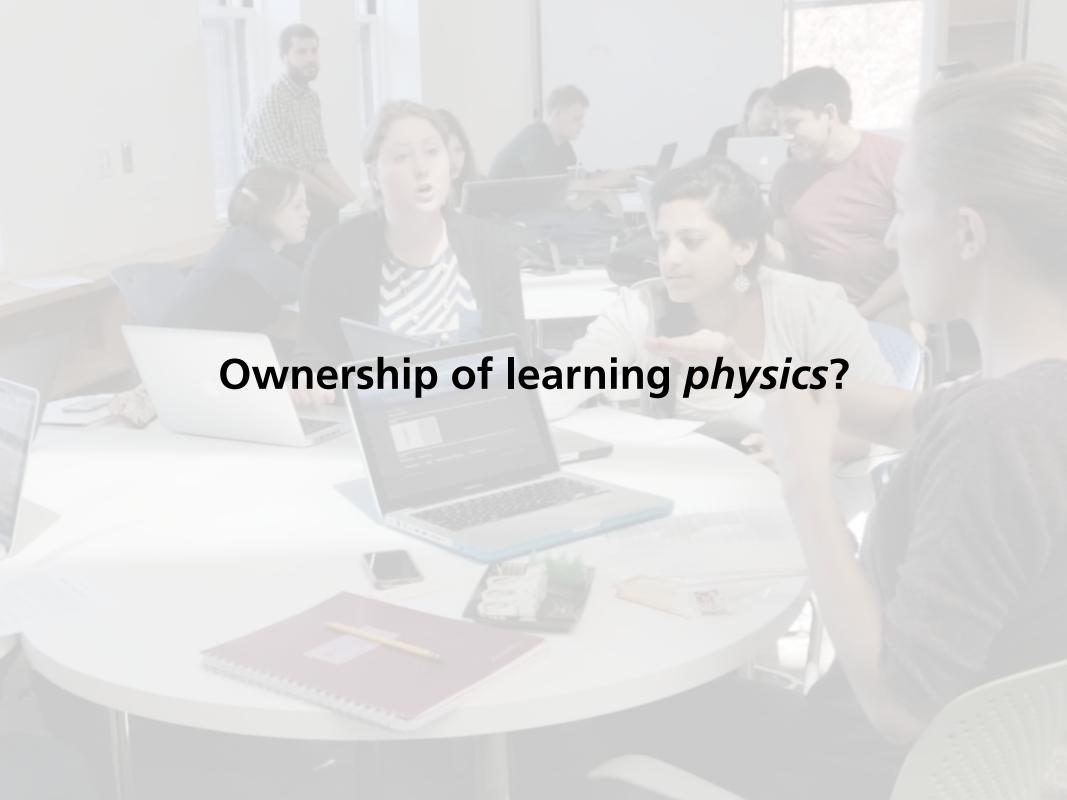


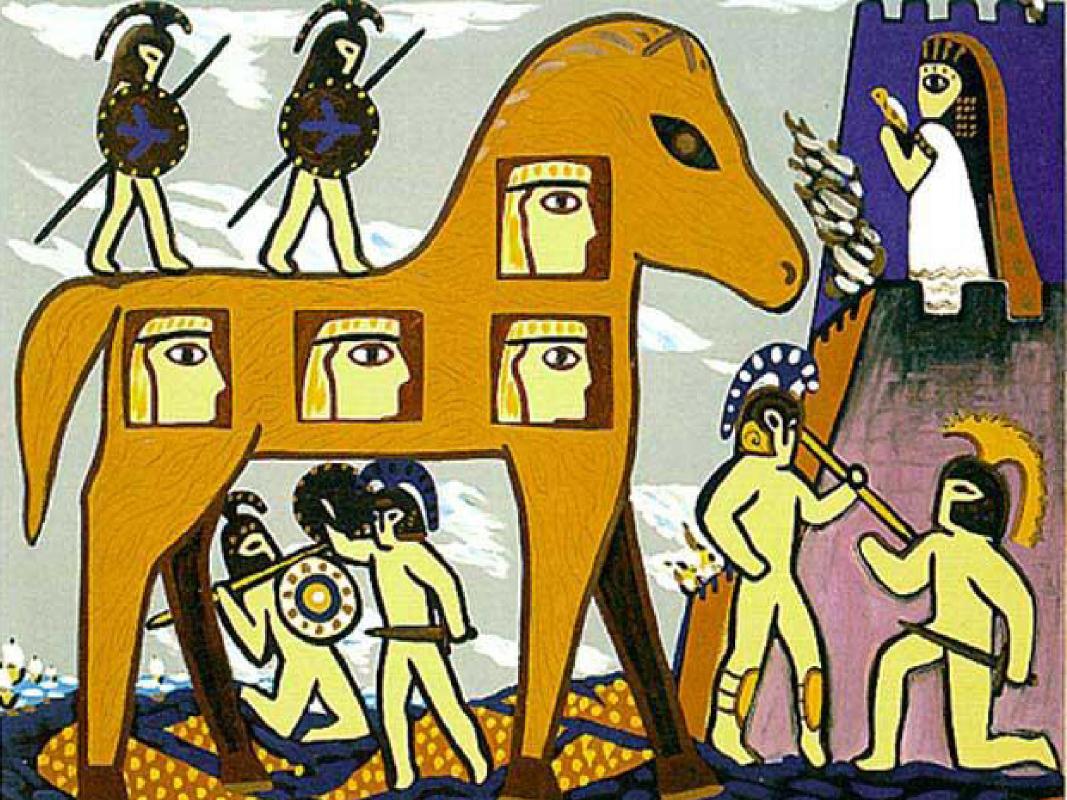
Flat space, deep learning

















2 approach



2 approach

3 results

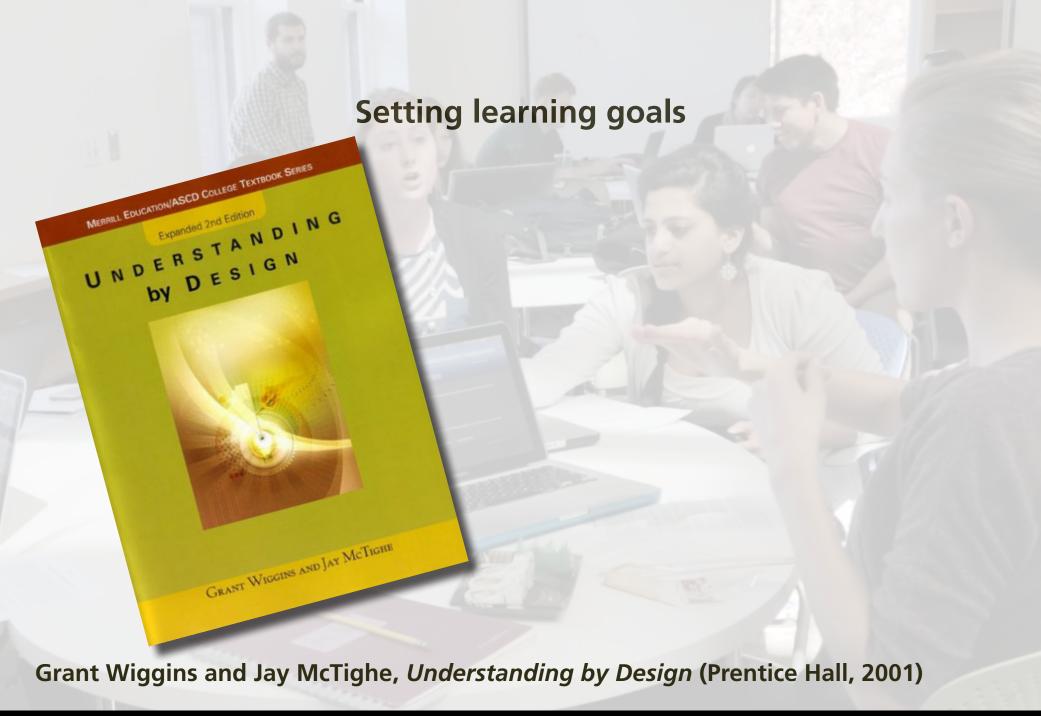


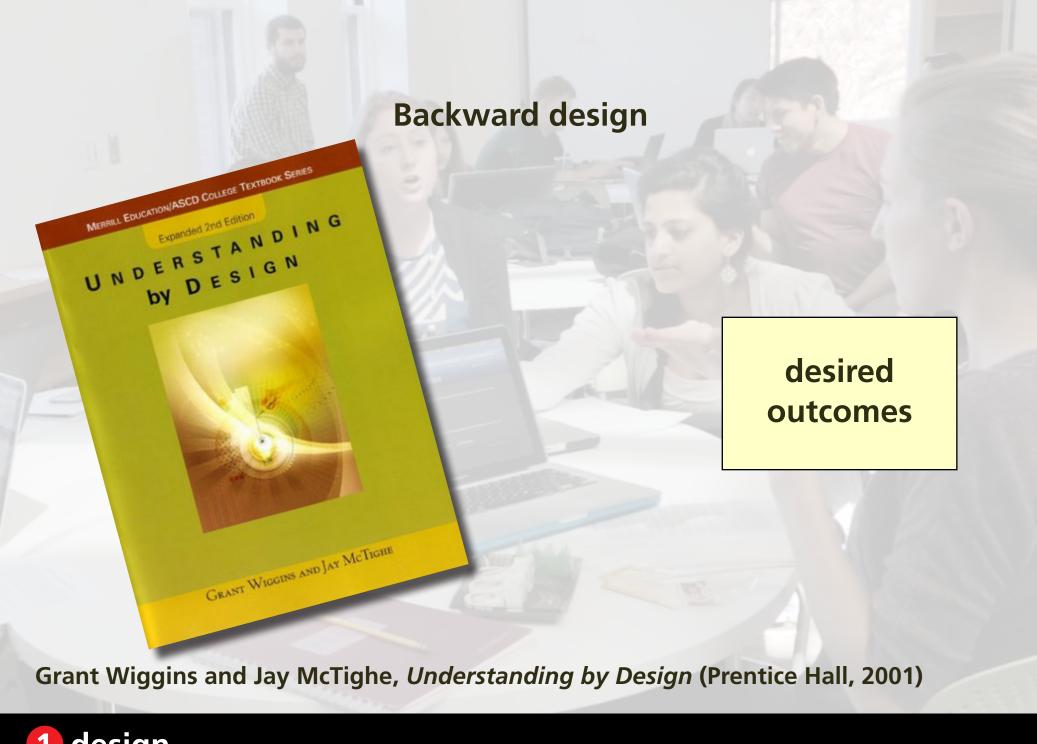
Four tracks, all modeled after standard course for majors

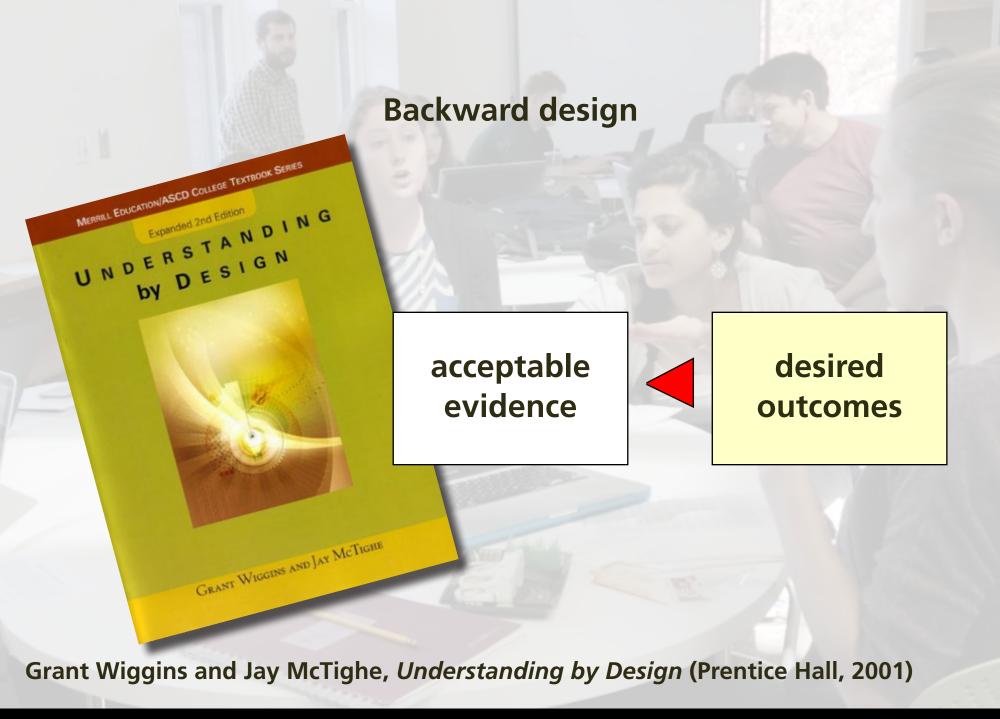
(don't satisfy needs of non-majors)

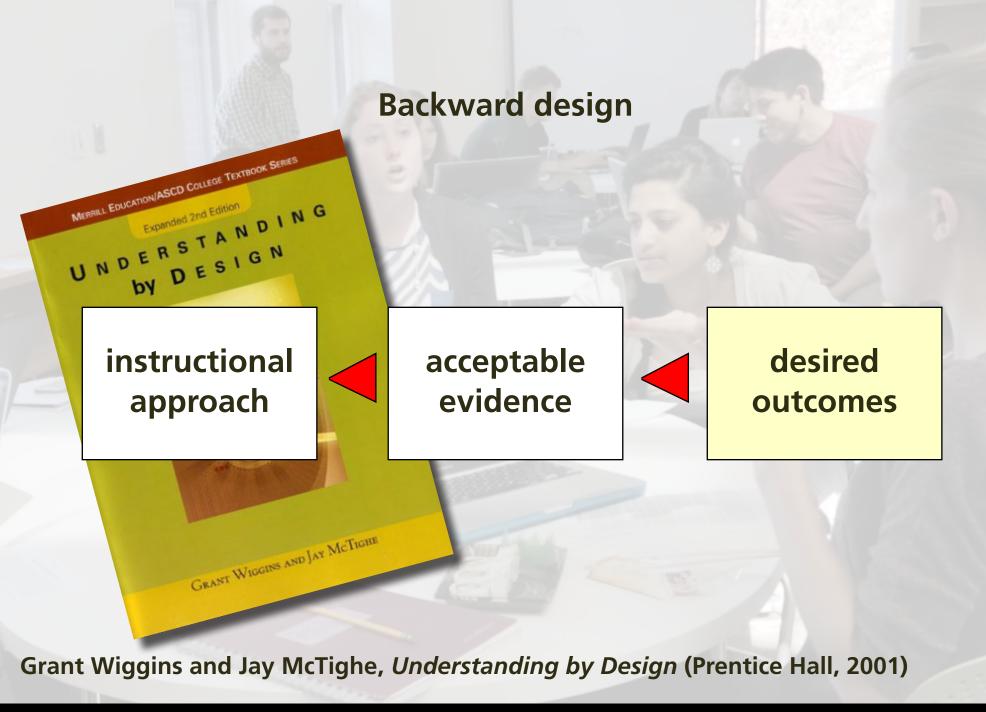
Need to:

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

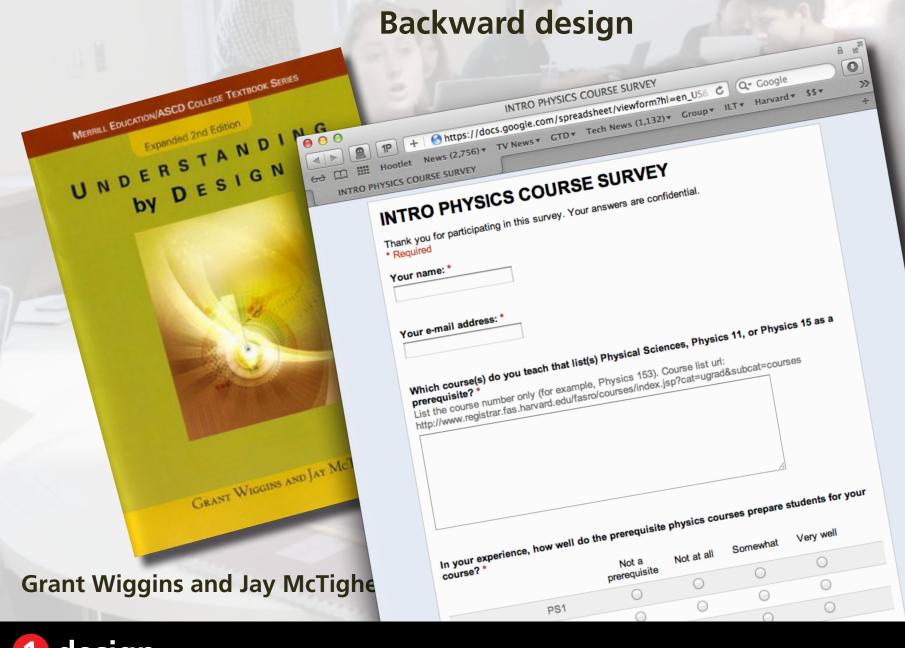














also designed to

Qualitative Analysis: Ine aumy to a disciplines qualitatively, including esumanon, or Quantitative Analysis: The ability to analyze and to solve problems !!! disciplines quantitatively, including use of appropriate tools, quantitative

Diagnosis: The ability to identify and resolve problems within comp plastication, form competencies of a hypothesis, and recommending identification, form competencies, and testing of a hypothesis, and recommending identification, form competencies, balar of the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommending in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis, and recommend in the ability to defend a hypothesis and a hyp visual thinking.

and which integrate knowledge, beliefs and modes of inquiry from mult Teamwork: The ability to contribute effectively in a variety of roles while respecting everyone's contributions. You will develop co

questioning, listening, and identifying multiple approaches and point munication: The ability to convey information and ideas effective to identify and address your own

After successful completion of this course, you will be able to... (with) Use independent study and research to tackle a problem COURSE GOALS

- 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 **Course** igoals, tequations

 symmetries, evaluate relevant relations

 Set up, solve, and interpret relevant.
 - - 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 meast
 - Describe how a measurement is performed and the limitation
 - software to control simple experiments and accumulate Hantify sources of uncertainty, and minimiz

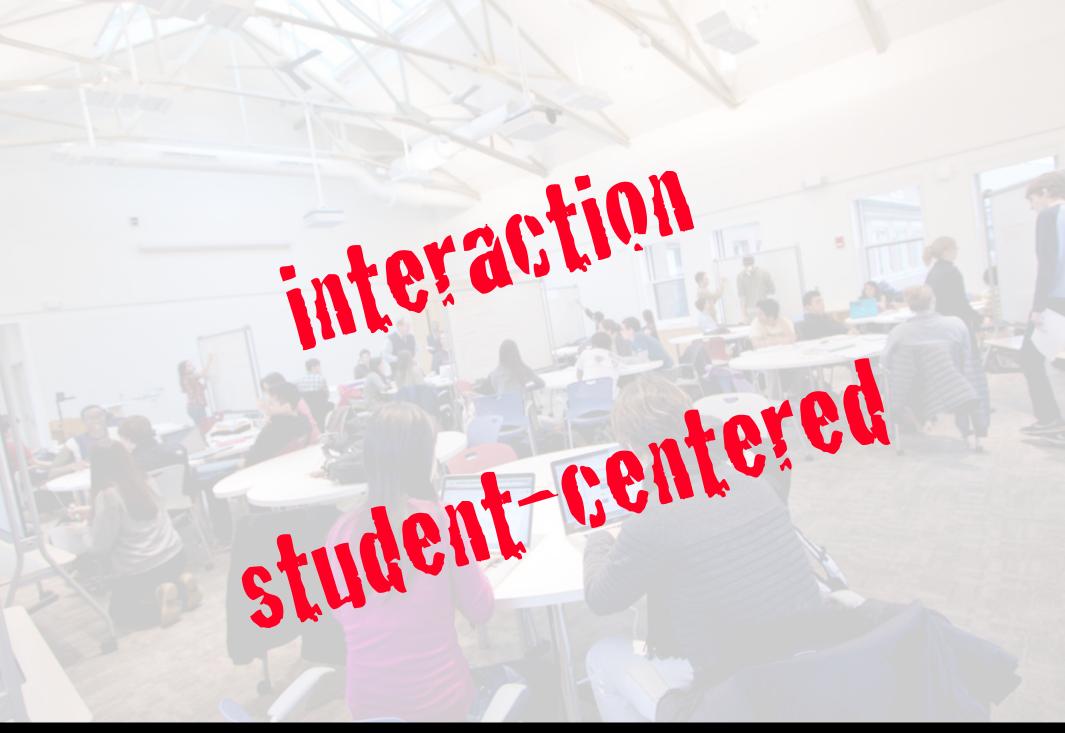
Describe the observations supporting the quantization and conservation and conservations Describe how the charge carriers behave in insulators and conductors. Explain polarization and how it gives rise to an electric force on a neutral objection polarization and how it gives rise to an electric force on a neutral objection when a conductor (insulator) is proposed by induction.

Describe what happens the process of th Explain what a field is and give examples of scalar and vector fields. Explain the conditions in which Coulomb's law is valid. distribution, exerts on a charged particle. wector field diagrams for a simple distribution of charged particle design









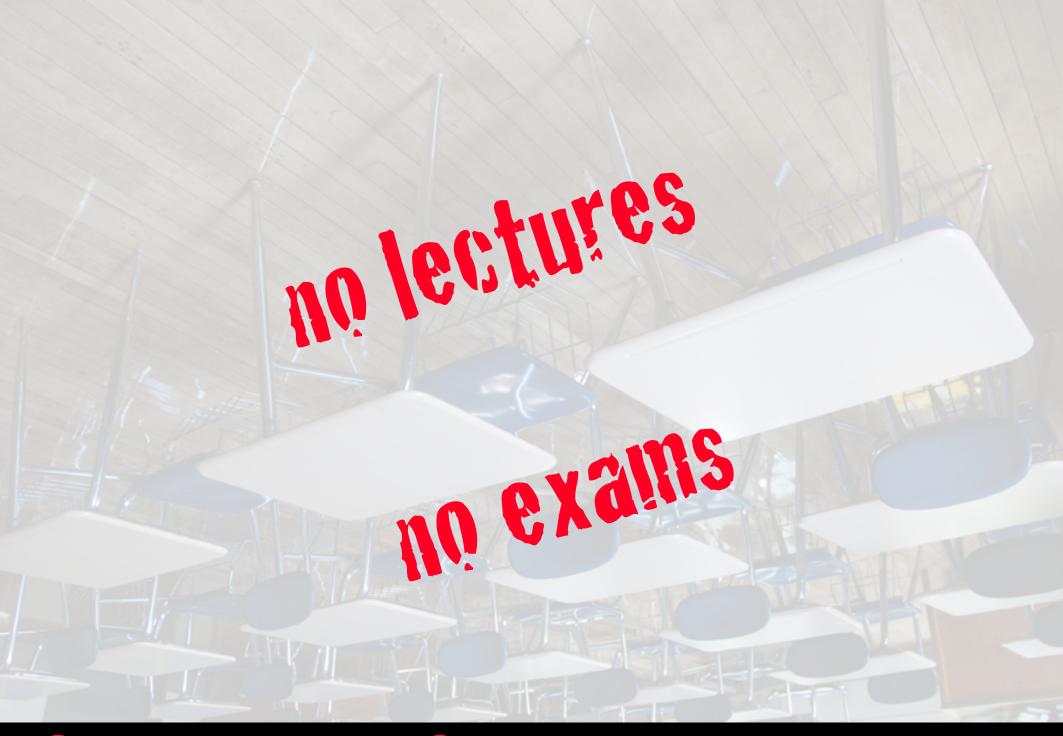


2 approach









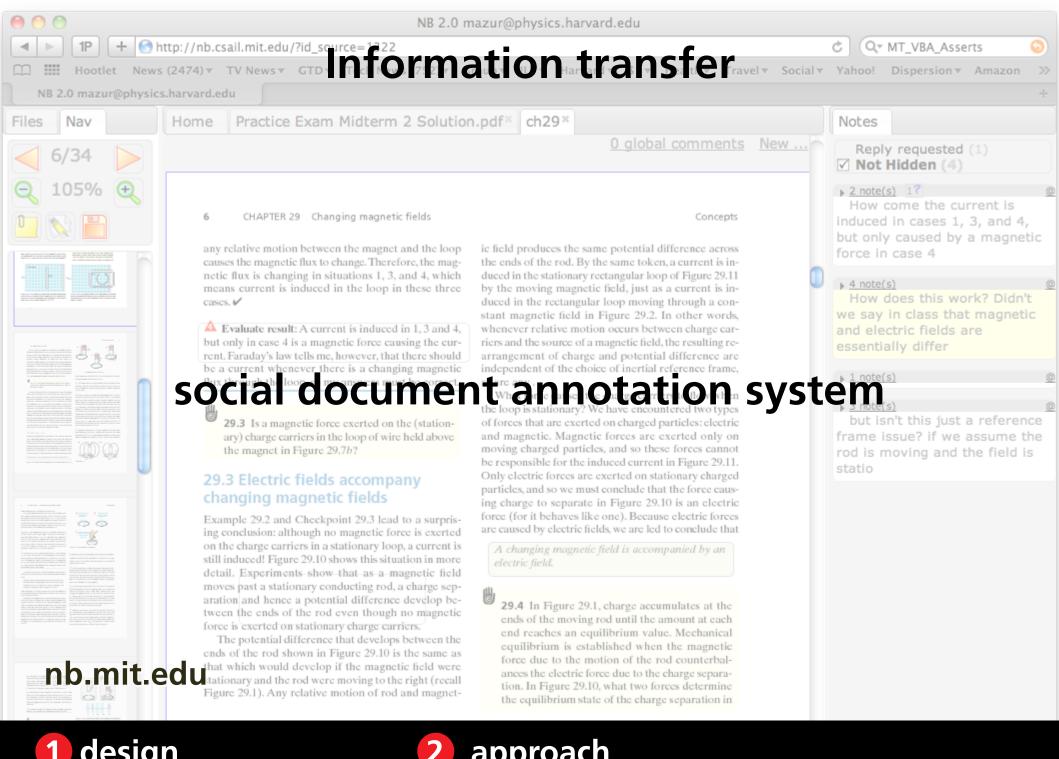
2 approach

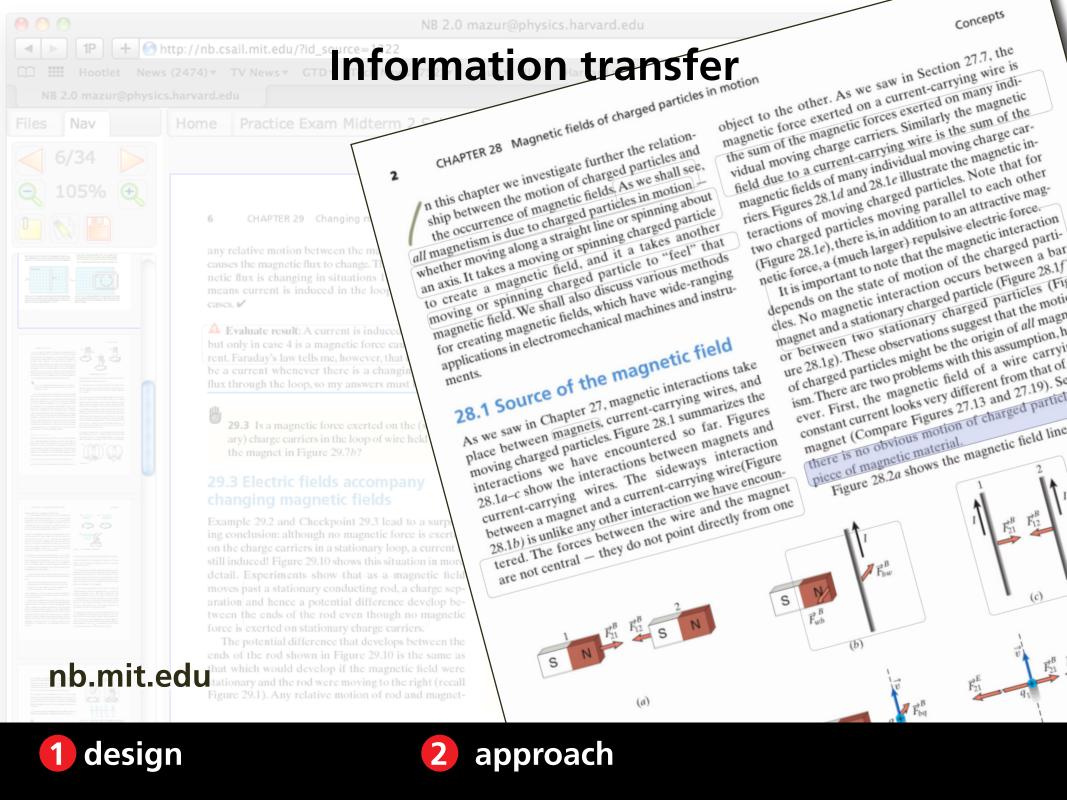
Three major components:

information transfer (out of class)

in-class activities

projects





Hootlet News (2474) TV News TV News GTD Information atransfer

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 moving via a current. Therefore, it meets their definition that it takes moving 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 ...

As we saw in Section 27.7, the ted on a current-carrying wire is netic forces exerted on many indige carriers Similarly the magnetic rent-carrying wire is the sum of the many individual moving charge car-Id and 28.1e illustrate the magnetic inoving charged particles. Note that for articles moving parallel to each other there is, in addition to an attractive mag-(much larger) repulsive electric force. tant to note that the magnetic interaction the state of motion of the charged partignetic interaction occurs between a bar stationary charged particle (Figure 28.1f stationary charged particles (Fig. bservations suggest that the moti might be the origin of all magn blems with this assumption, h tic field of a wire carryi ery different from that of es 27.13 and 27.19). Se is no obvious motion of charged particl nt current looks Figure 28.2a shows the magnetic field line

Hootlet News (2474) * TV News * GTD Information atransfer

Student 1 - 25 Feb, 04:55PM

Yeah, this is where I'm confused. From the first paragr 'It takes a spinning charged particle to create a magnet there is motion of charged particles in a piece of ma magnet ple?). How does this reconcile?

Student $2 - 26 \mathbf{E}_b$,

that here is no O S motion, but they are in fact May meets their demntion that it takes it ing par refore, ent. agne eate

Stulet 5 – 2 Mar, 09:00AM

I agree that the motion is not "obvious" in the nake cause must be atomic.

Student 2 - 2 M

estion above - I guess there Oh the ess n ary, but since even when an object is stationary isn't a sorce the is a magnetic force. It's when everything, including (thus no onary that there is no obvious motion. the part

Student 4 – 4 Mar, 01:05PM

Is there ever a situation in reality where everything, even the particles are not ...

in Section 27.7, the t-carrying wire is ted on many indilarly the magnetic is the sum of the noving charge care the magnetic inticles. Note that for arallel to each other there is, in addition to an attractive mag-(much larger) repulsive electric force. c interaction harged partitant to note that the m tween a bar the state of motion of Figure 28.1f gnetic interaction occu rticles (Fig at the moti of all magn a wire carryi is no obvious motion of charged particl Figure 28.2a shows the magnetic field line









estimation

blend of best practices

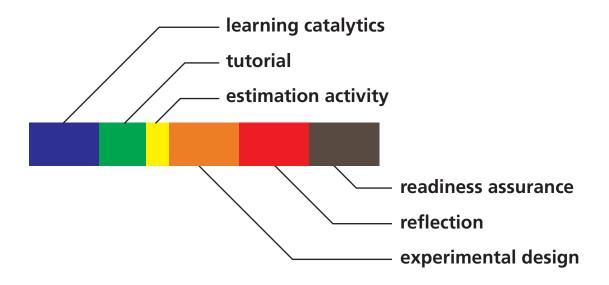
reflection

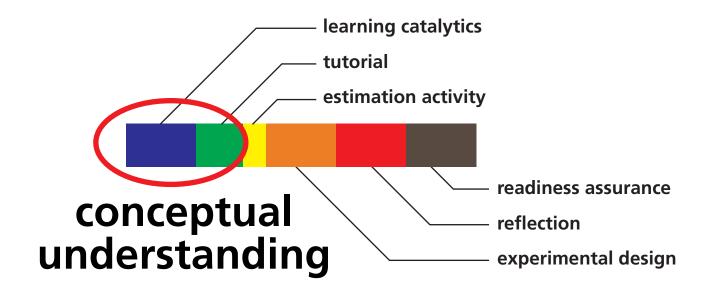


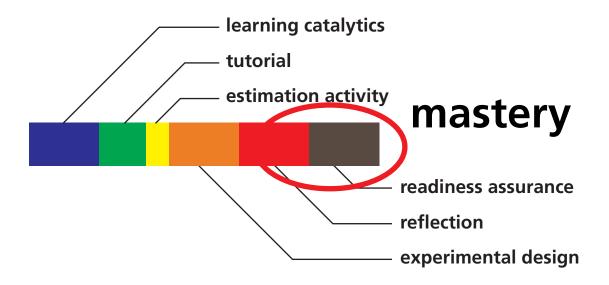


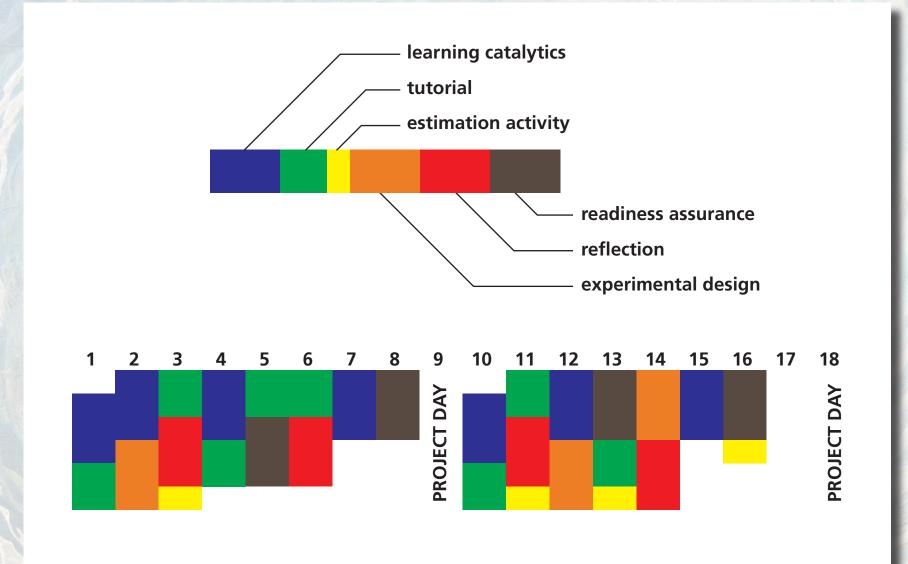


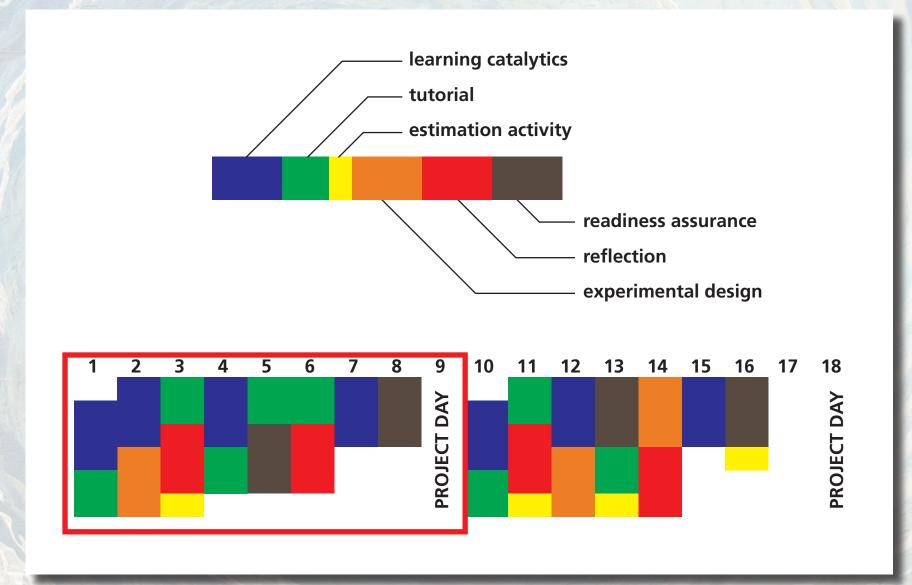


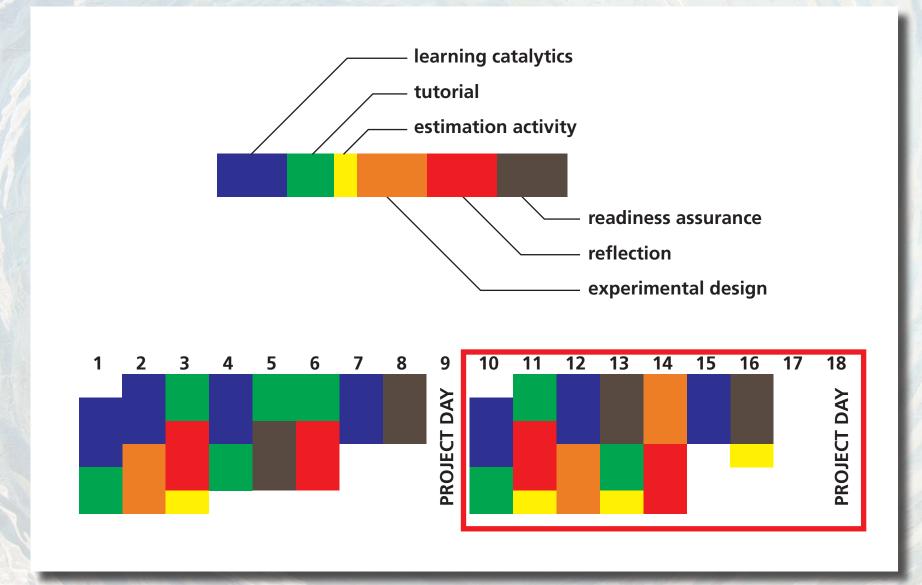


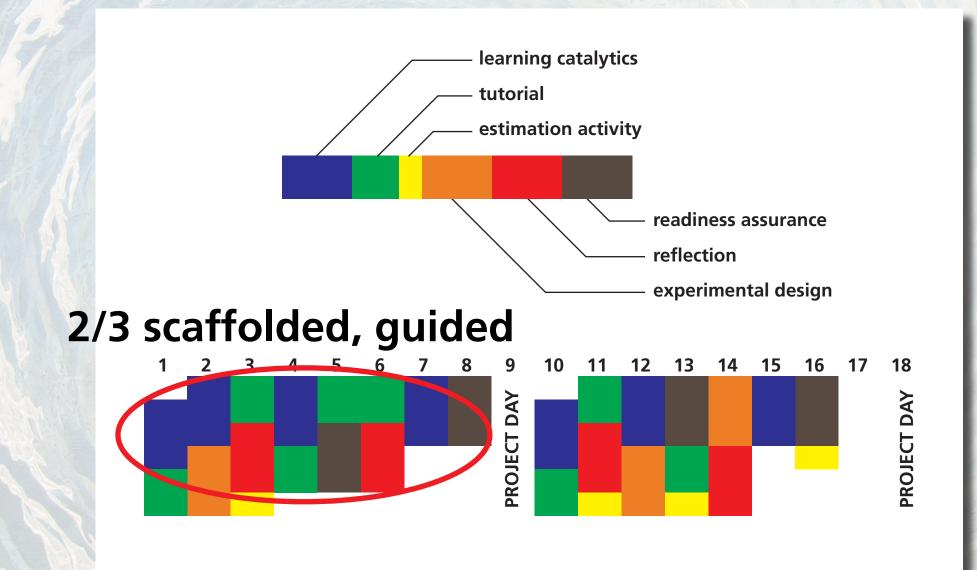


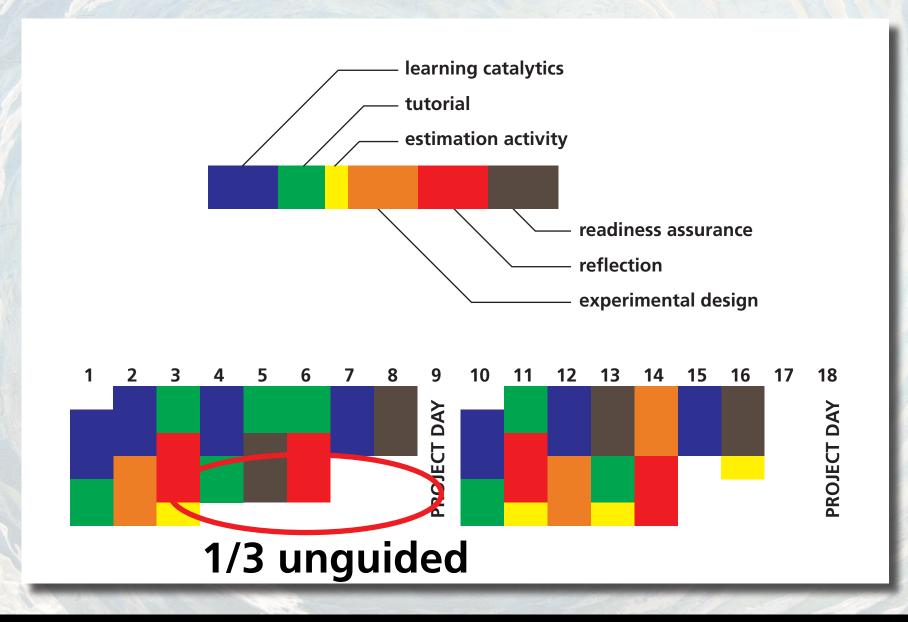


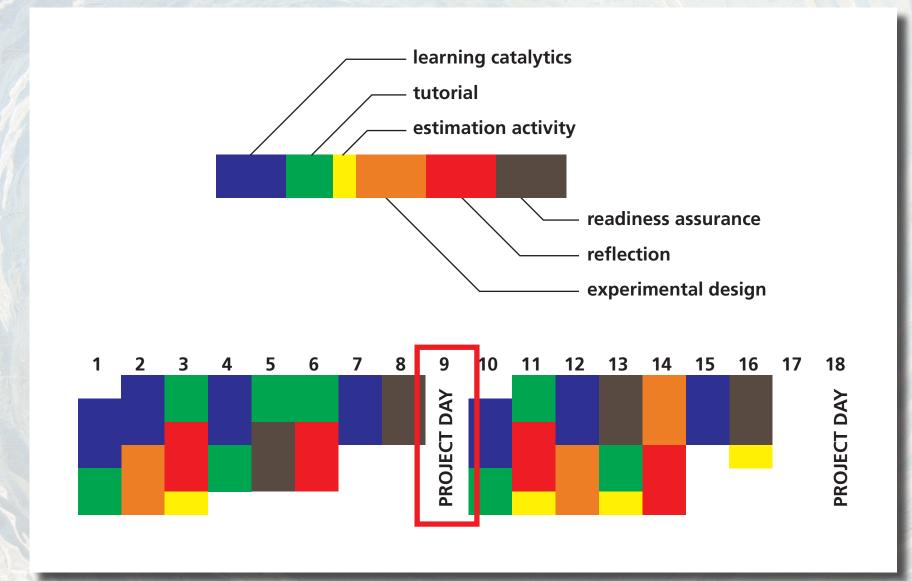


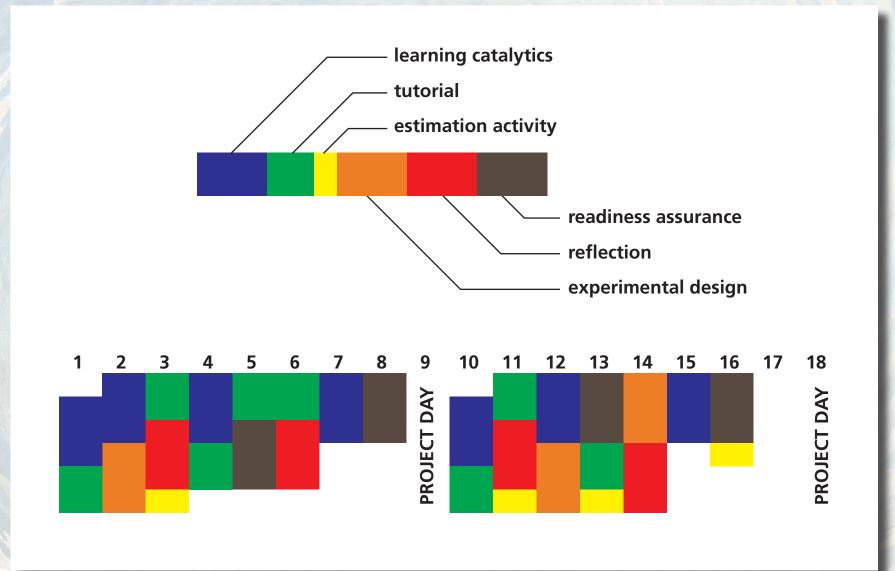


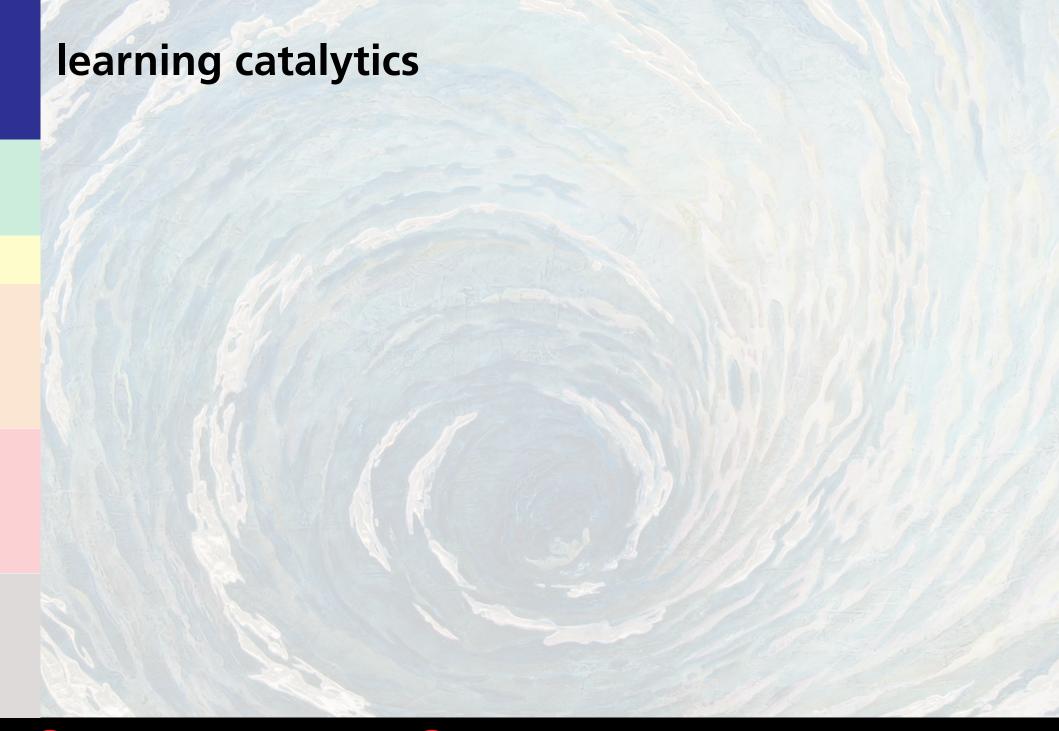




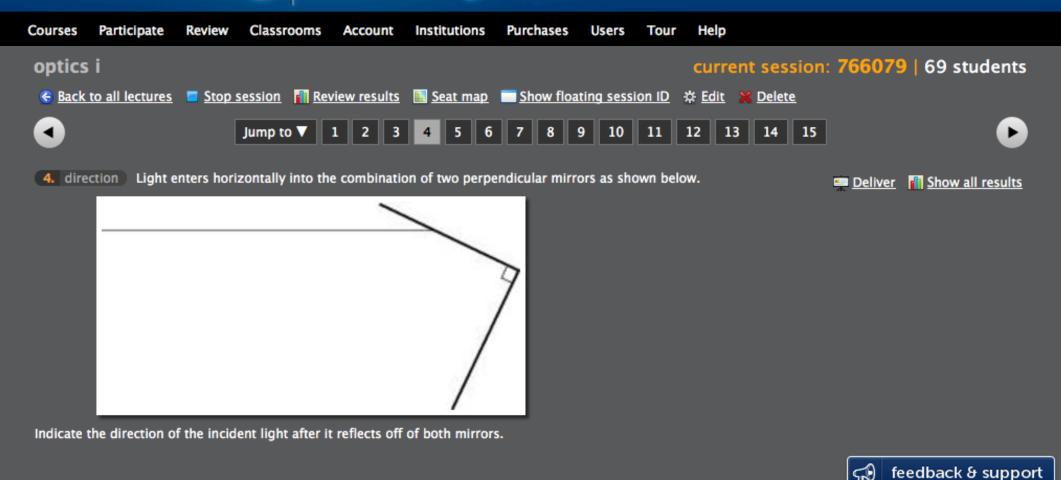




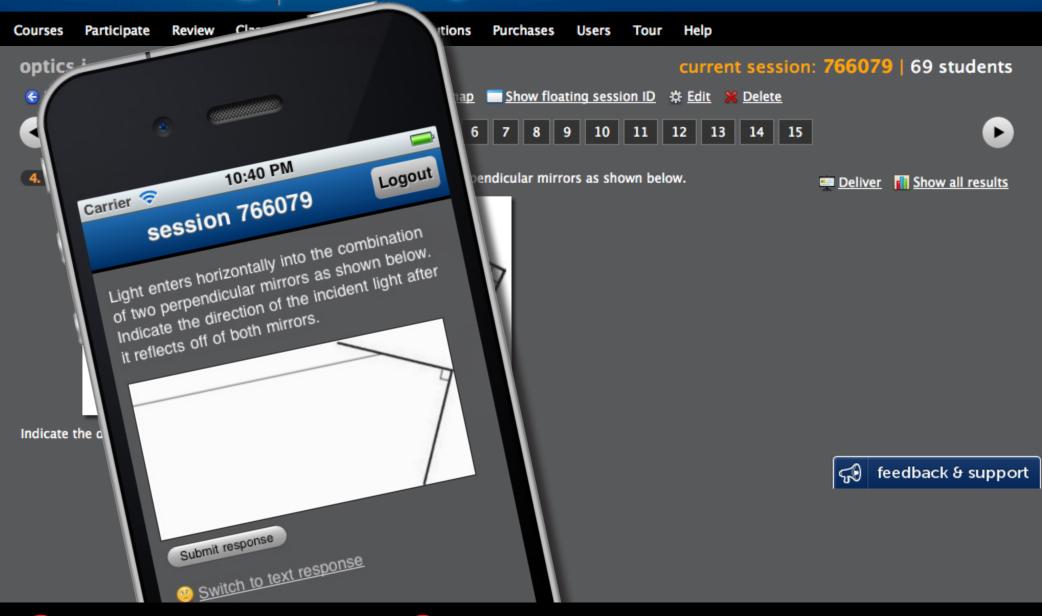




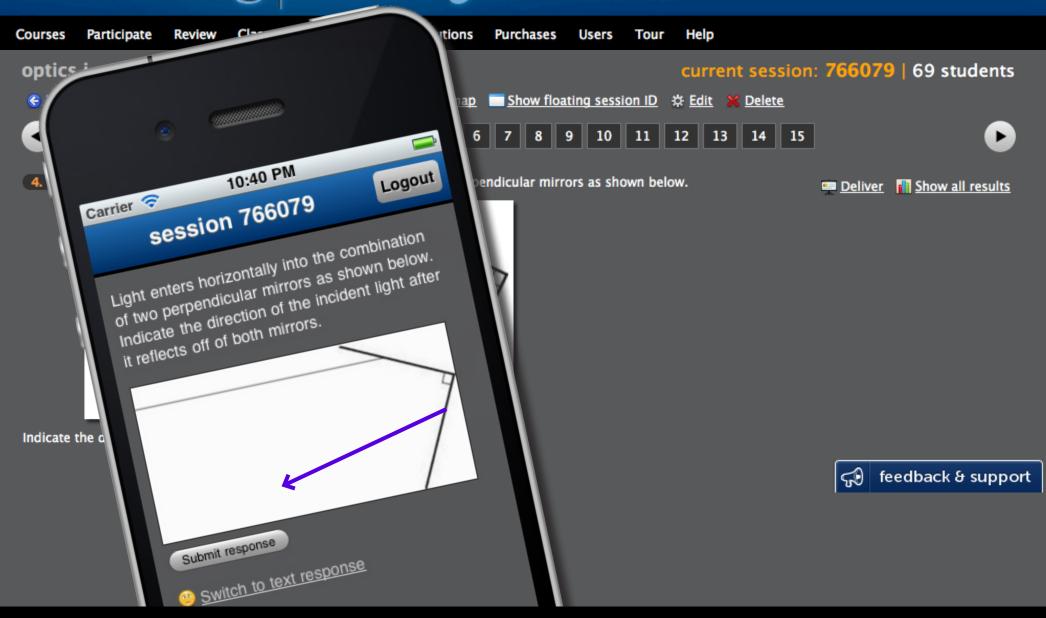
learning catalytics goal: develop conceptual understanding



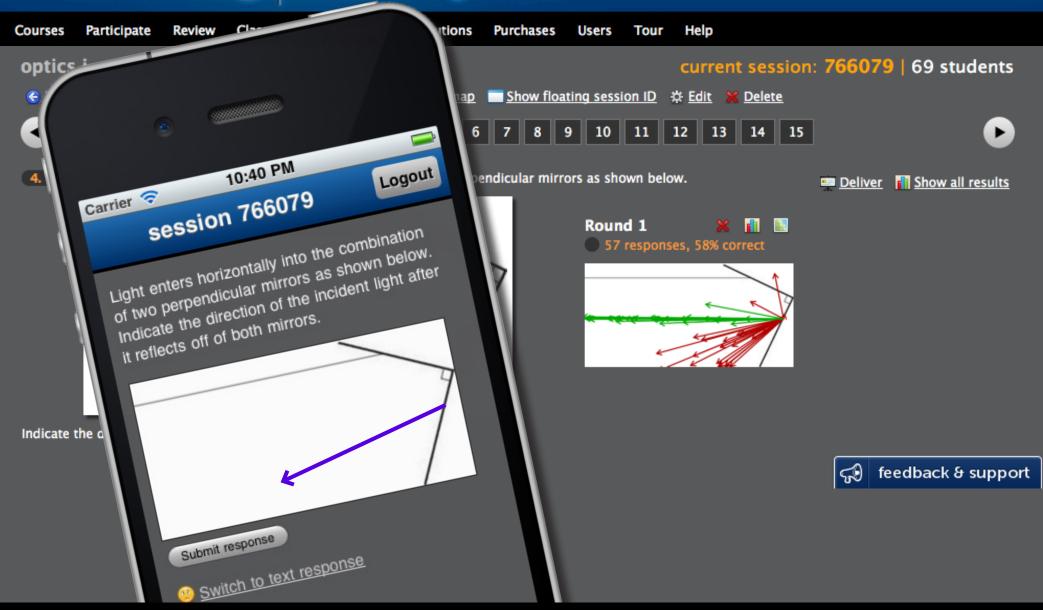






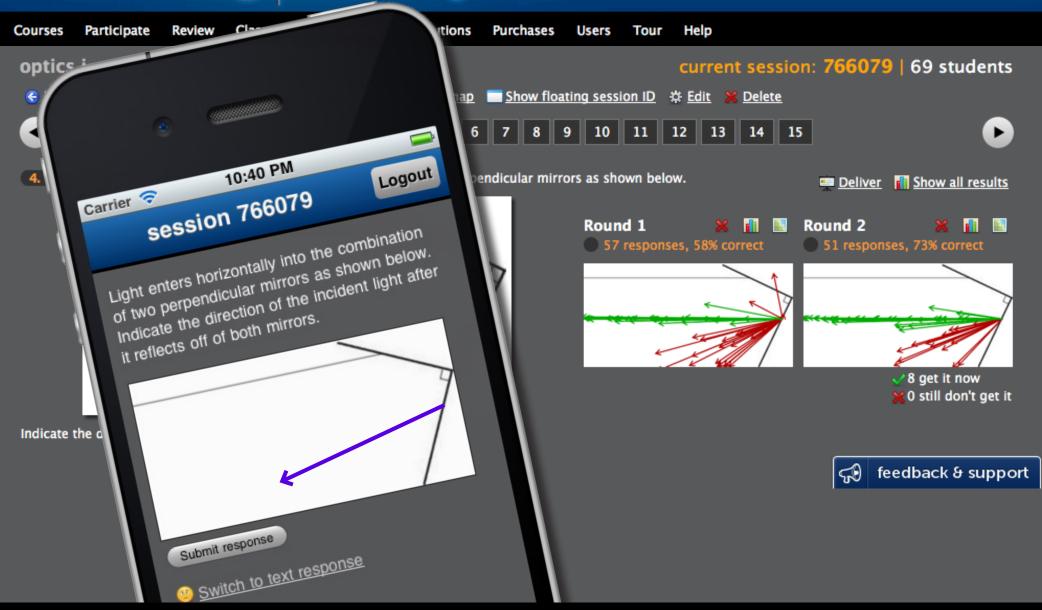






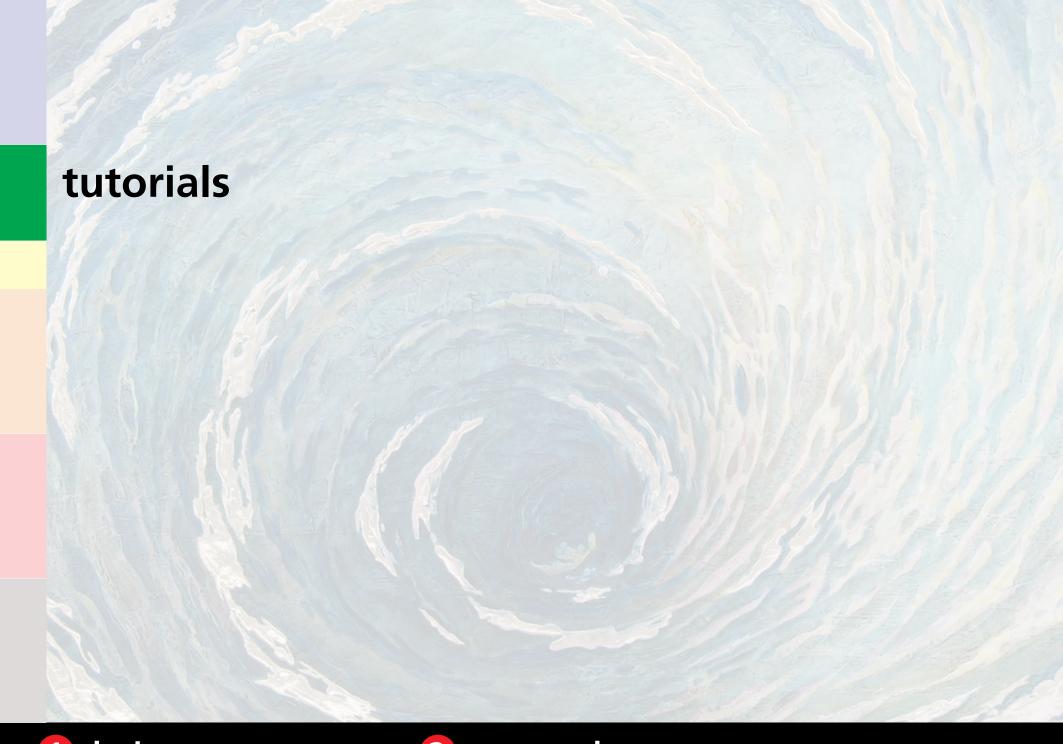




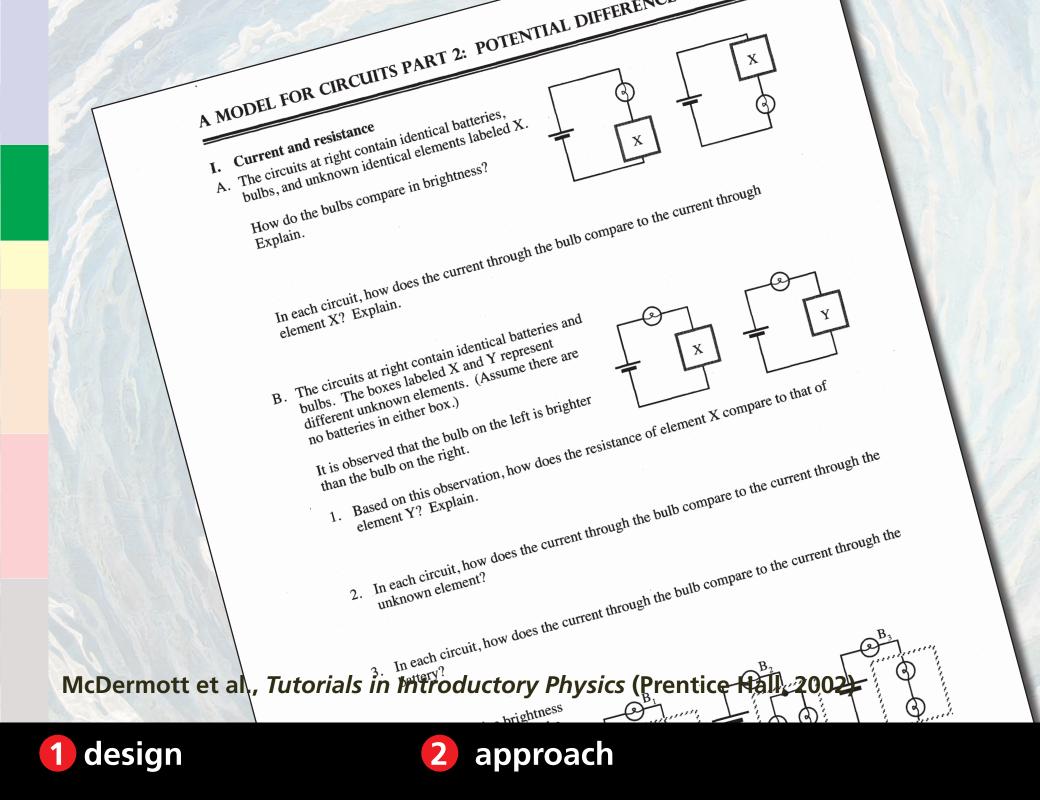


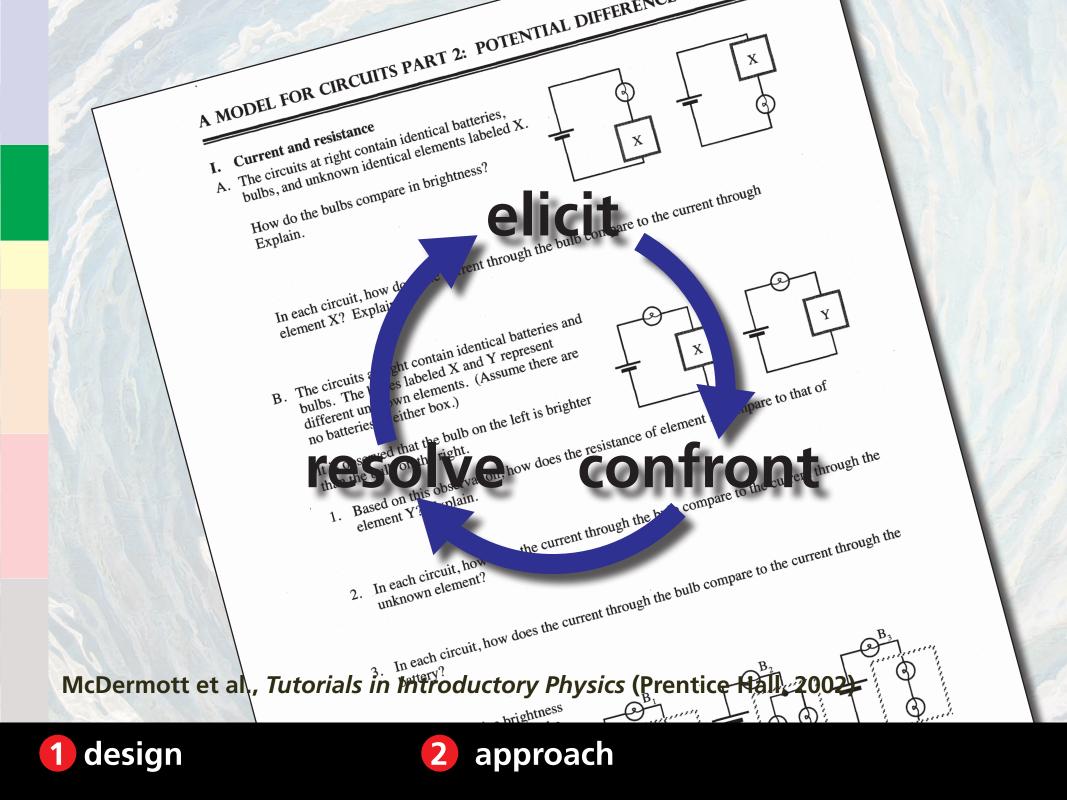


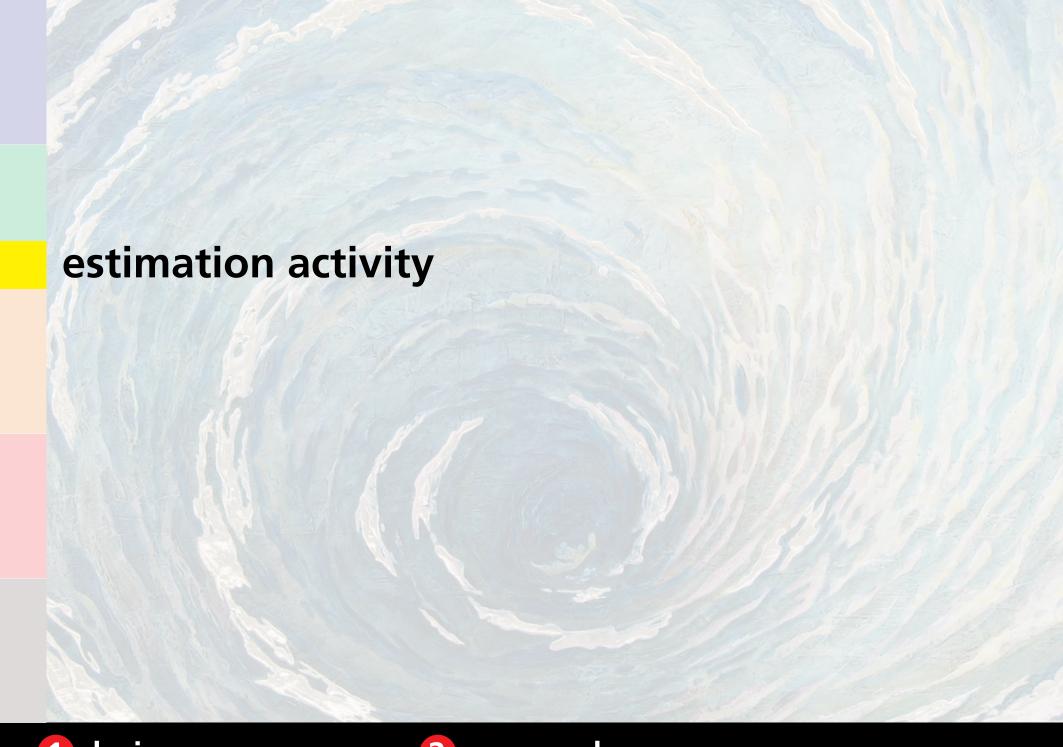
000











estimation activity goal: develop qualitative reasoning skills design approach

Estimation Activity 2

Instructions: estimate (not guess!) the quantities below to the nearest order of magnitude. The first team to correctly enter all values wins. 2. How much current can one wearing a silver bracelet generate by walking in front of a microwave? (Assume you act as insulators) are wearing thick layer of clothes and your arms/bodies somehow act as insulators. 1. Design a solenoid that can generate the same amount as the Earth's magnetic field.

correctly enter all values wins.

2. The matring thick layer of clothes and your arms/bodies somehow act as insulators) 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. 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. 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 copper wire around a football field 3 times and by plugging it into a car battery.

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

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

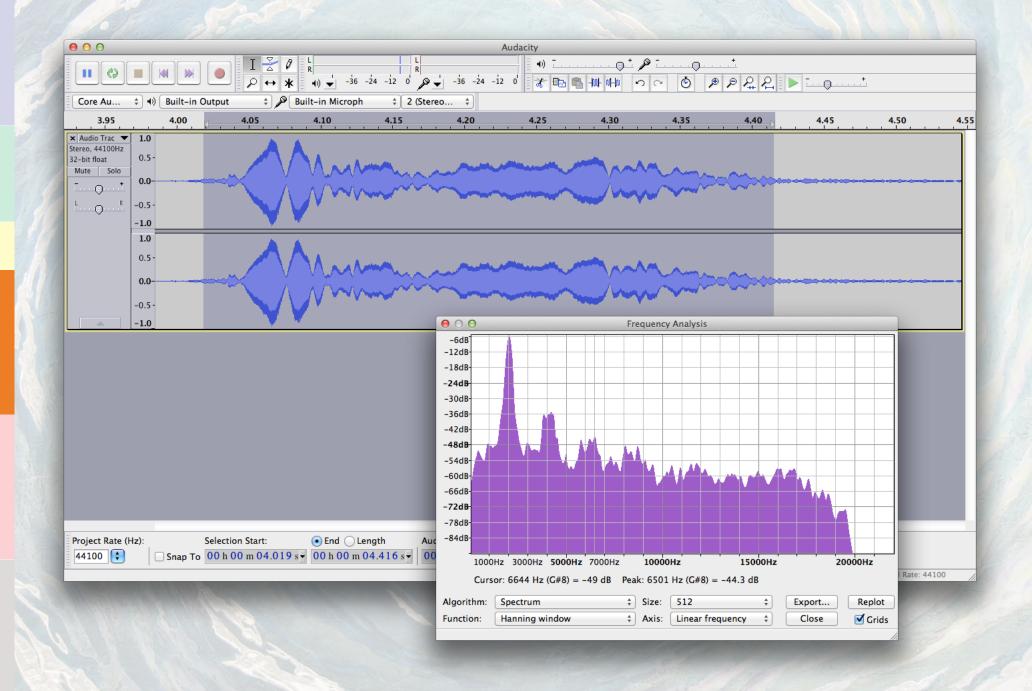
You expect this coil generated?

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



experimental design activity

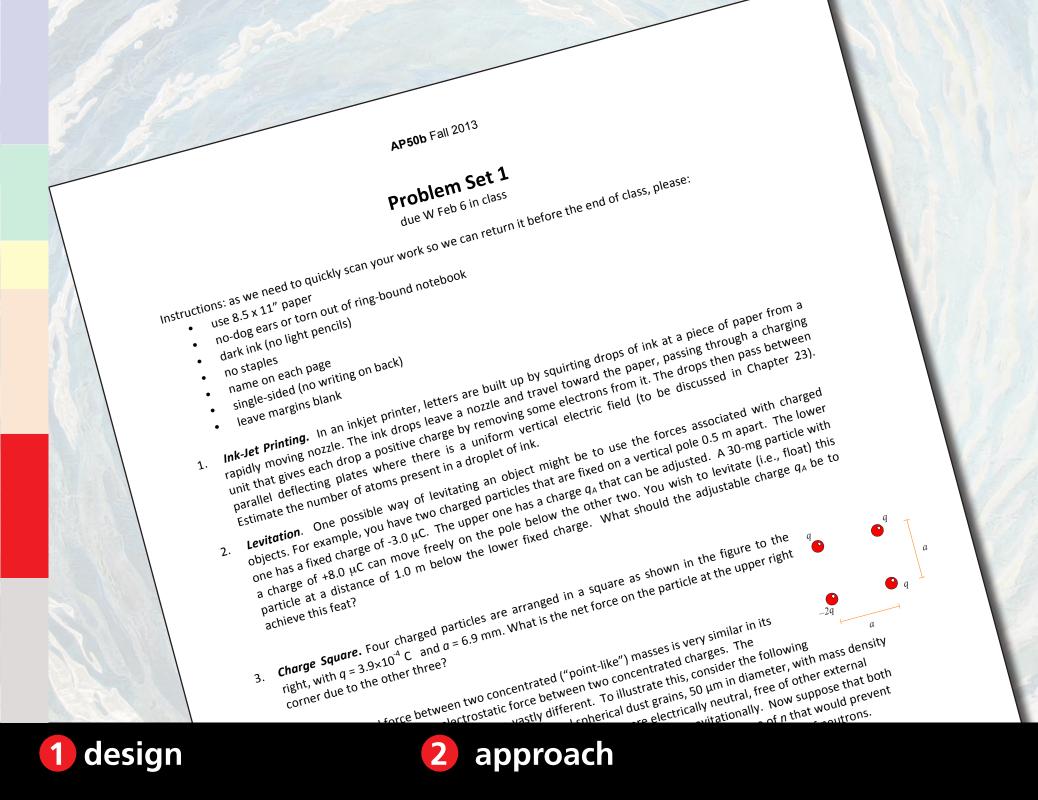
goal: develop experimental skills

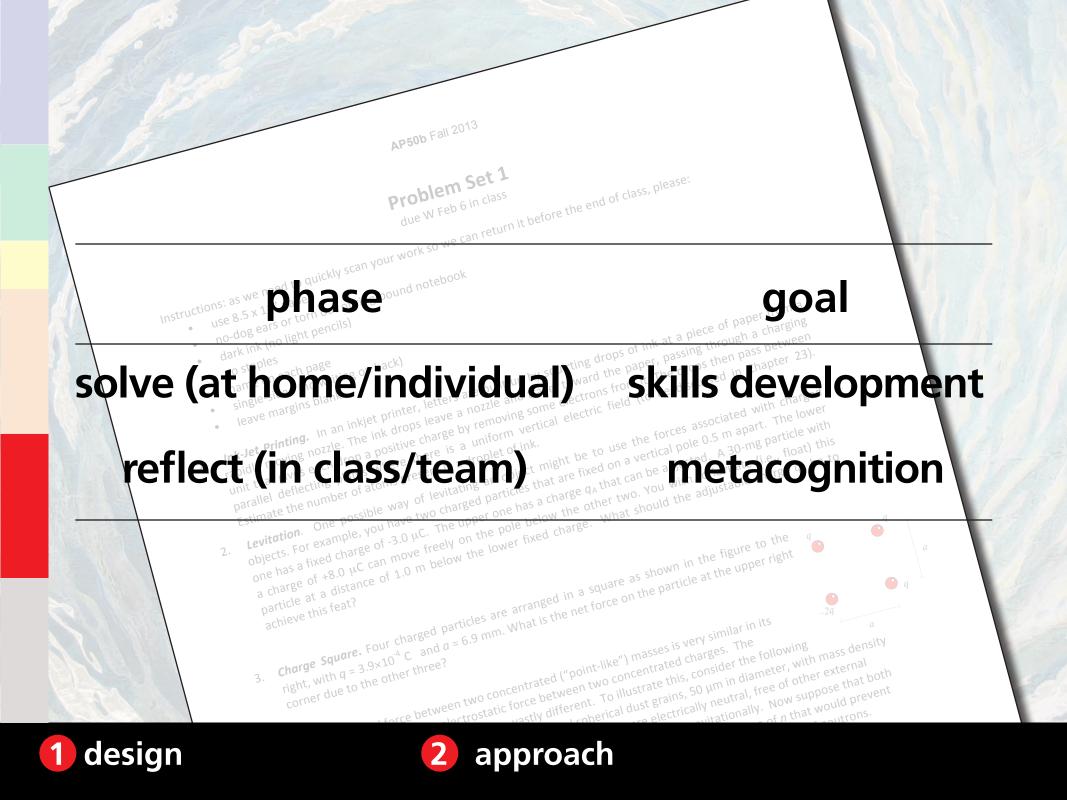




goal: develop problem solving and metacognitive skills

homework reflection





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 The goal of the problem sets is to develop problem-solving skills, not just to test your ability to obtain the right and team work. The rubric mirrors the 4-step procedure used in all Worked Examples in the textbook (see also answer. You will receive the problem sets a week before they are due. Each problem sets involves both individual sets in the textbook (see also 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 resources. but you may not consult 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 neonle. nor collaborate with your neers. Treat this stage of the problem-solving process as an opento work on the problem set alone. You can consult the textbook and online resources, but you may not consult book/open-notes exam (except that your peers. Treat this stage of the problem-solving process as an open-solving process as an open-see helow). It's ok

other people, nor collaborate with your peers. Treat this stage of the problem-solving process as an open-to try hard and not succeed at first. but you must attempt every problem. If you get stuck, try to describe your book/open-notes exam (except that your work done at home is not evaluated on correctness—see below). It's ok thought process so vou are prepared for a discussion with vour team in class. You may only use blue or black ink. to try hard and not succeed at first, but you must attempt every problem. If you get stuck, try to describe 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, and/or correct vour solutions. and plan what you need to review (if anything). During this stage, you may Team phase (in class): On the due date of the problem set, you will work with your team in class to complete, only use red ink to write on your problem sets (pens will be provided in class). After the first 45 minutes, your improve, and/or correct your solutions, and plan what you need to review (if anything). During this stage, you may use to confirm your solutions. After an additional 45

only use **red ink** to write on your problem sets (pens will be provided in class). After the first 45 minutes, your team must submit the team's corrected problem sets together with each team member's selfteam will be provided with a solution set which you may use to confirm your solutions. After an additional 45 each team must submit the team's corrected problem sets together with each team member's selfevaluation and indication which problems need to be reviewed in a Learning Clinic. Important: It is the team's responsibility to ensure that <code>all_team_members_provide_complete_solutions, because_team_score_complete_solutions, because_team_score_complete_solutions_co</code>

that your entire team understands the material. Scoring

Important: It is the team's responsibility to ensure that all team members provide complete solutions, because that vour entire team understands the material.

It is the team's responsibility to ensure that all team members provide complete solutions, because solutions, because the material. Your problem set will be evaluated on the five domains below, using the standard 0-3 scale (3 = all problems; $2 = \frac{1}{2} \frac{$ Your problem set will be evaluated on the five domains below, using the standard 0–3 scale (3 = all problems; 1 = more than 50% of the problems, 0 = 50% or fewer of the problems; 2 = work volu did hefore coming to class (anything not written in red) more than 70% of the problems, 1 = more than 50% of the problems, 0 = 50% or tewer of the problems). For $\frac{1}{2}$ 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. Devise Plan Execute Plan

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

Carry out your plan, explaining each store Articulate your thought prog clearly defined. an can co.

approach

Eval

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

Getting Started

State the important information and summarize the properties 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 can complete this part 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 you worked on the problem alone, as well as any mechanic completed in class.

1 design

re domains we will only evaluate the work you did before coming to c **Getting Started** State the important information and summarize the property of Note any assumptions you're making. 4-step procedure Vrite down a plan of attack before diving into the so **Devise Plan** smaller, manageable segments. Identify which physical r **Execute Plan** Carry out your plan, explaining each step in writing. You A ticulate your thought process at each step (including cearly defined, and your diagrams should be labeled. If an complete this part 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 you 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

Getting Started

State the important information and summarize the properties of th

Devise Plan

individual evaluation

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 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 you worked on the problem alone, as well as any mechanic completed in class.

Getting Started

State the important information and summarize the provided Note any assumptions you're making.

Devise Plan

Write down a plan of attack before diving into the seasonaller, manageable segments. Identify which physical responses to the provided segments.

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 you can complete this part in class with help from your team

team evaluation

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.

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

Execute Plan

Evaluate Plan

Reflection

Getting Started

Single the important approximation and summarize the provided hyperson in the important approximation and summarize the provided hyperson is an approximation of attachbourse divided hyperson in smaller, manageable segments. Note that which physical research is a smaller, manageable segments. Note that which physical research is a smaller of the segments.

Carry out year plan arolate an analysis of the graph proposed to the step (including leady affine and purely dams should be labeled. If you have the step it class with help from your team

em evaluation

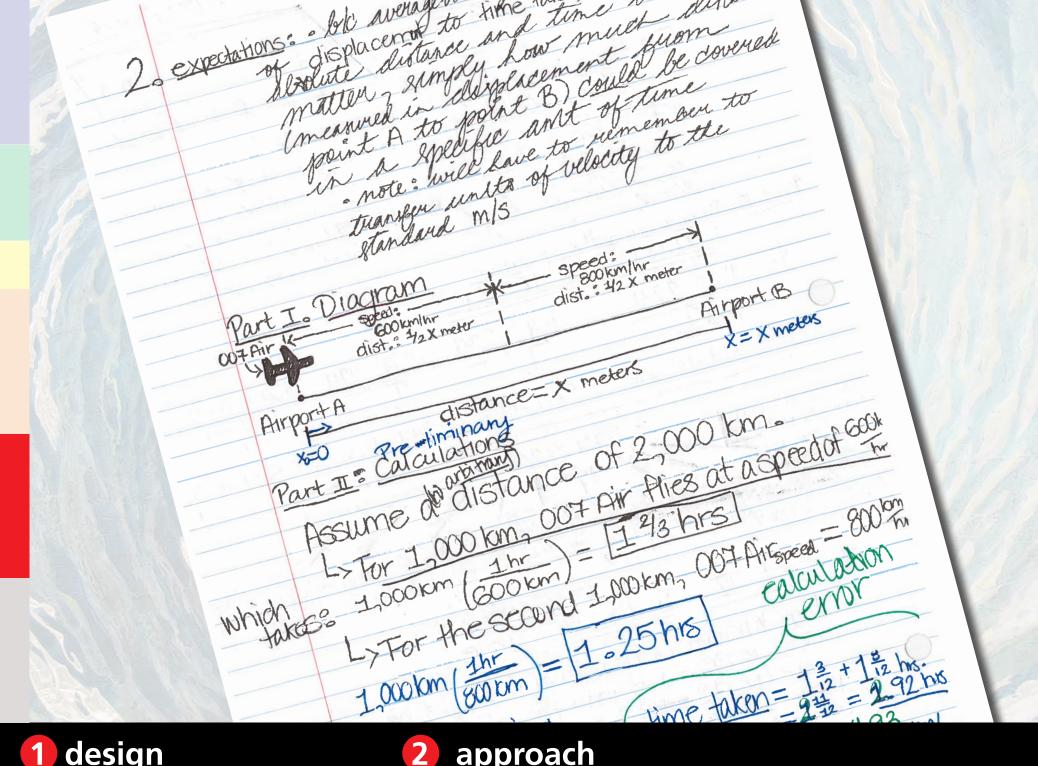
The ck each solution for reasonableness. There are man the symmetry of the solution, evaluate limiting or situations with known solutions, check units, use dimen of magnitude of an answer. If you get stuck on this step class with help from your team.

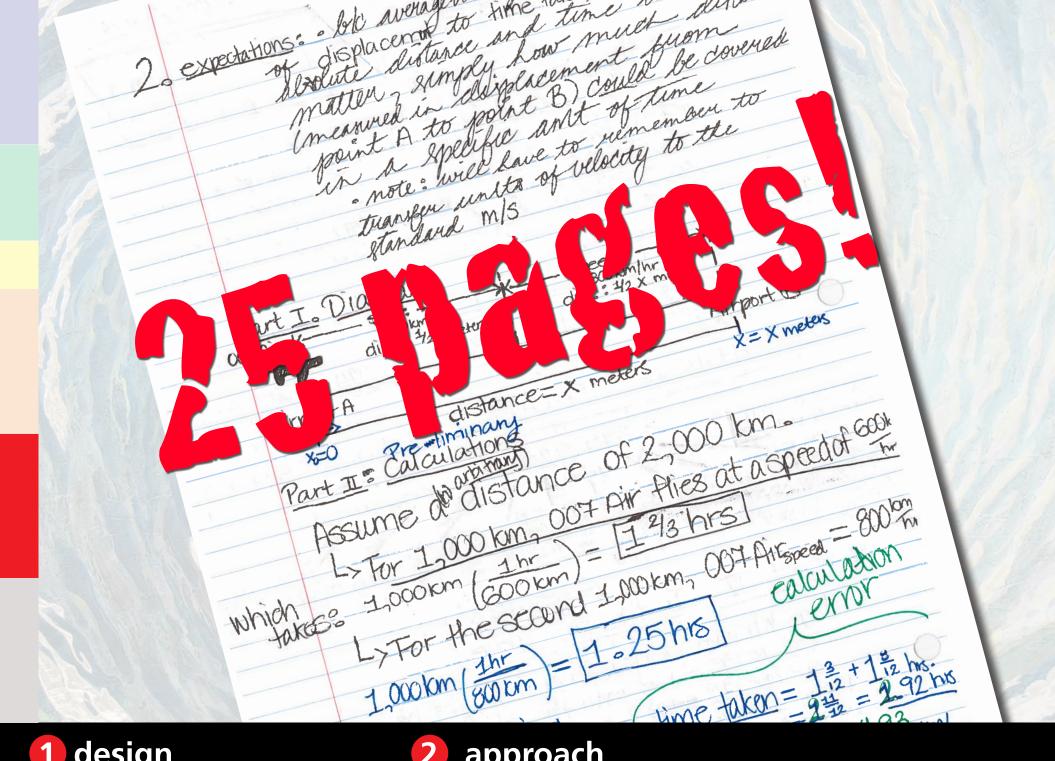
Clearly identify and explain any conceptual errors you worked on the problem alone, as well as any mechanic completed in class.

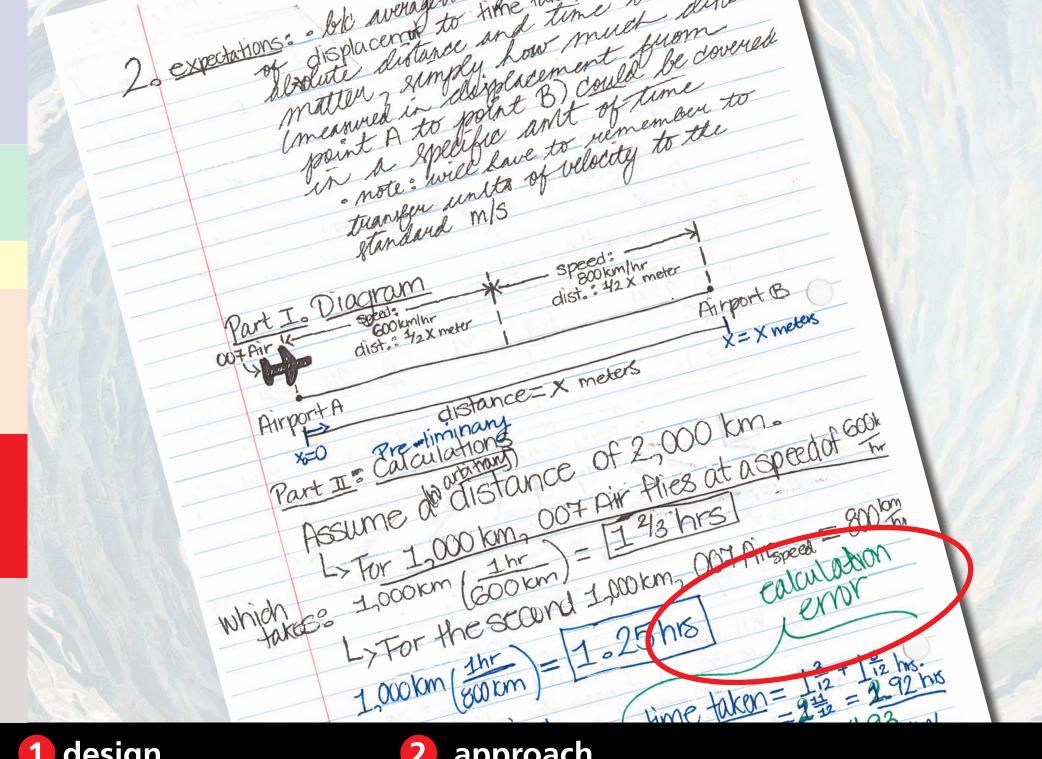
Execute Plan

atr la

Reflection

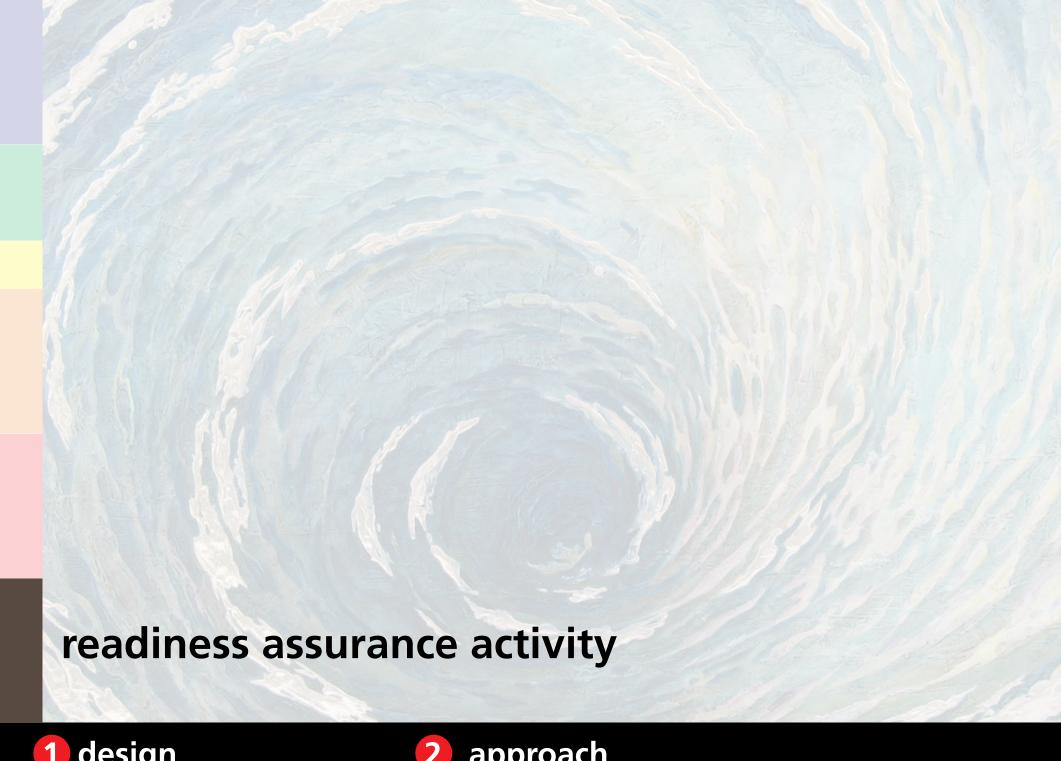






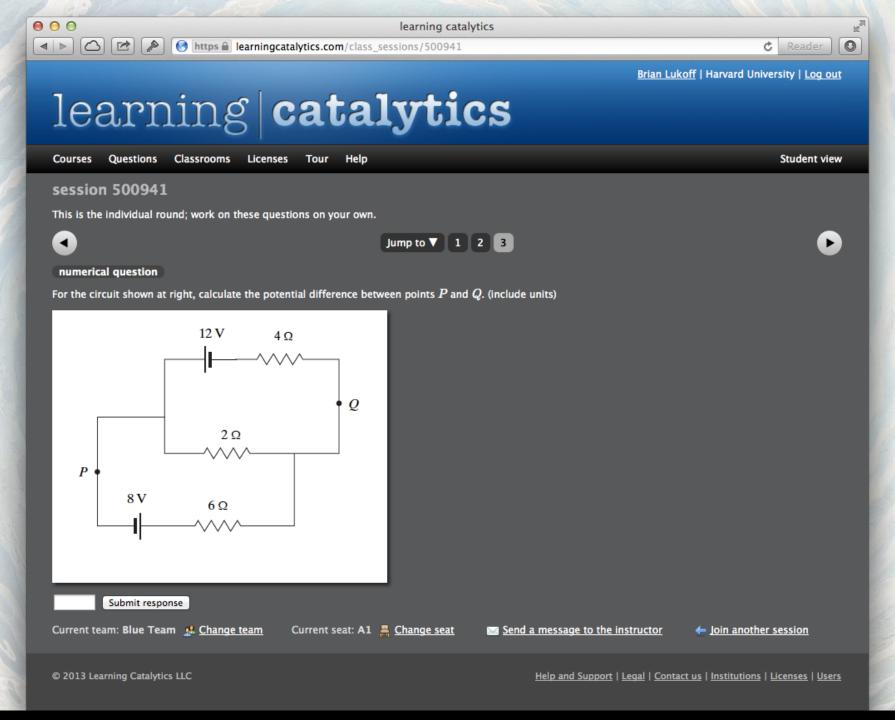
"I was inspired and encouraged to do these problems on my own with the promise of collaborative work [the next day]"

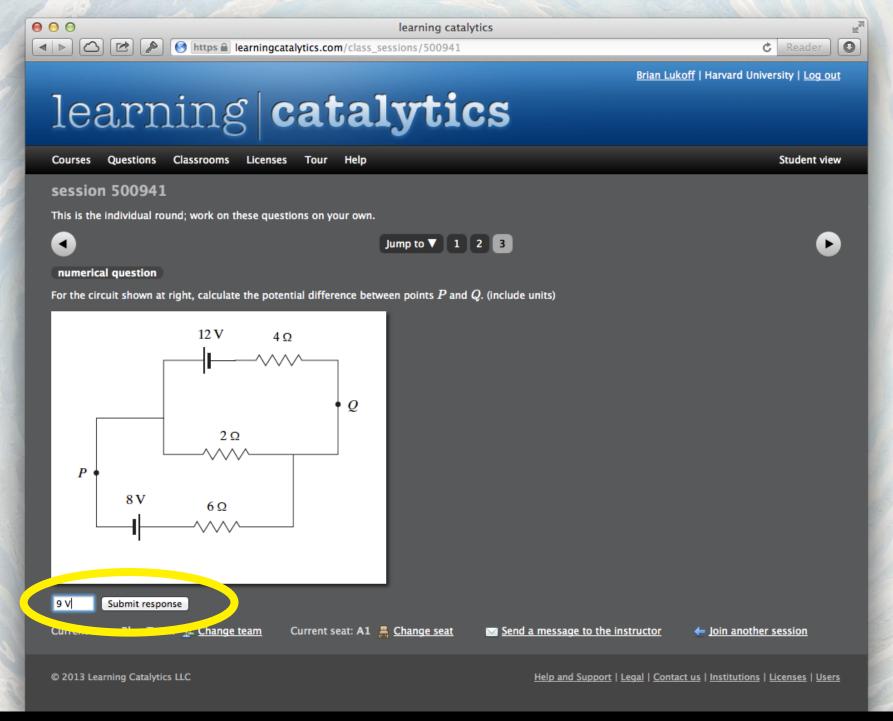
"I felt less pressure to find the right answer and more freedom to explore" design approach

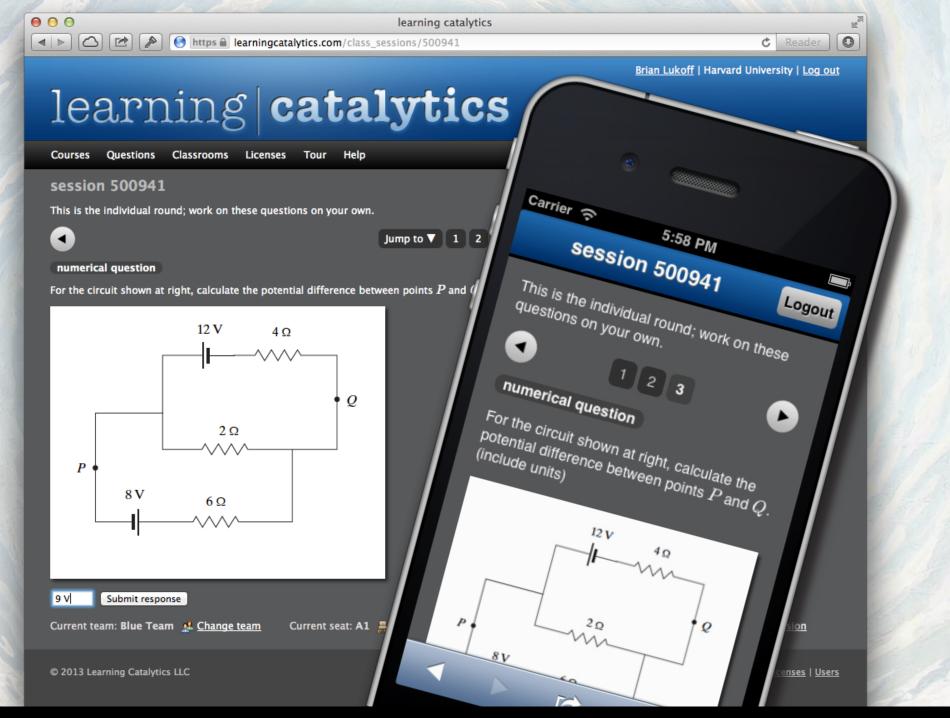


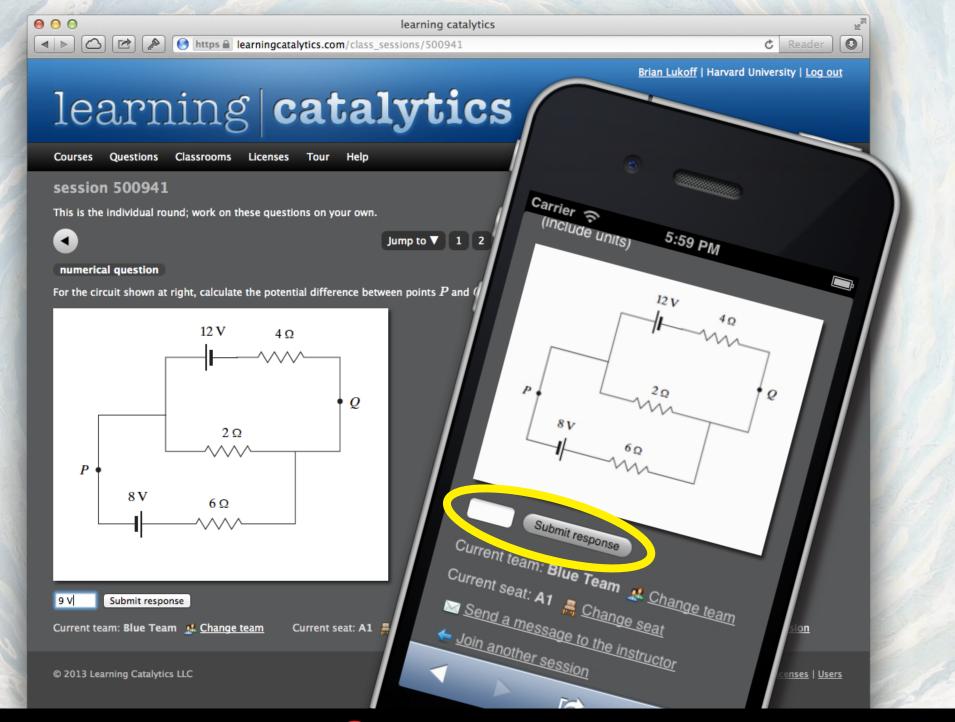
goal: formative assessment collaborative learning

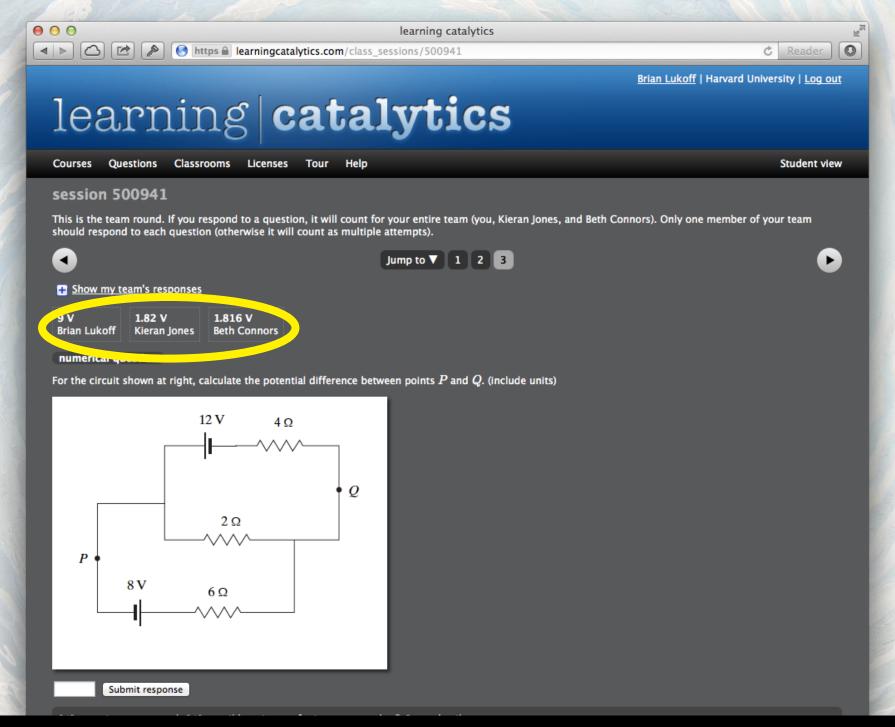
readiness assurance activity

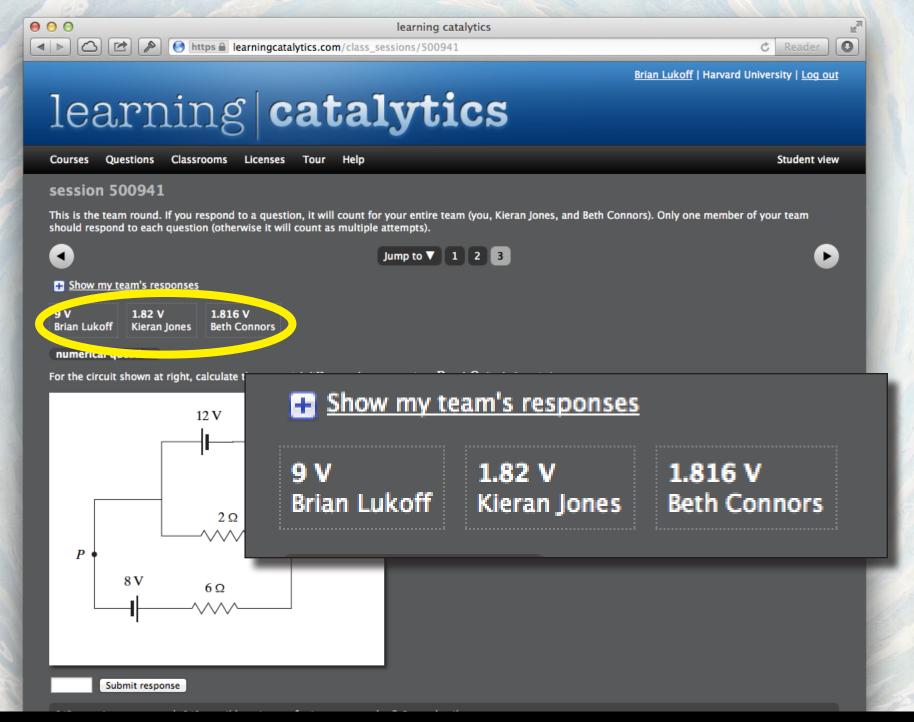




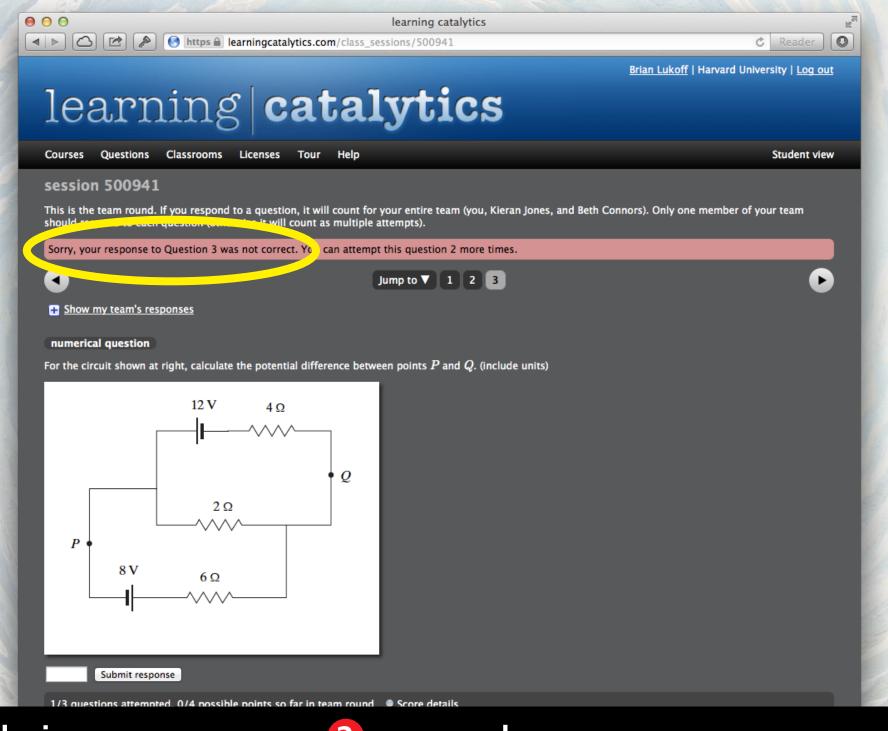


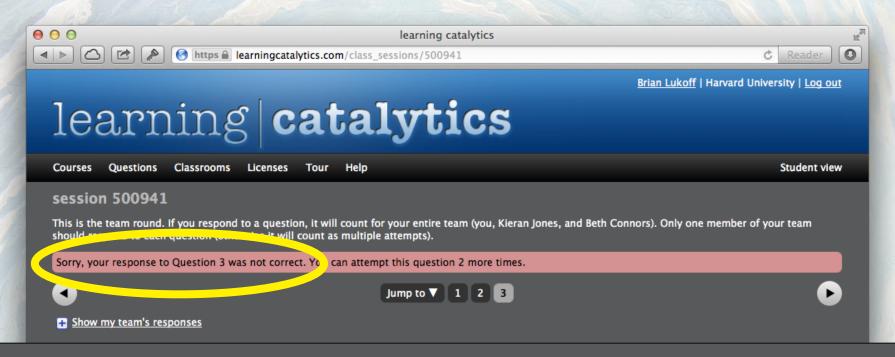






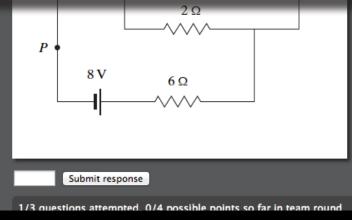


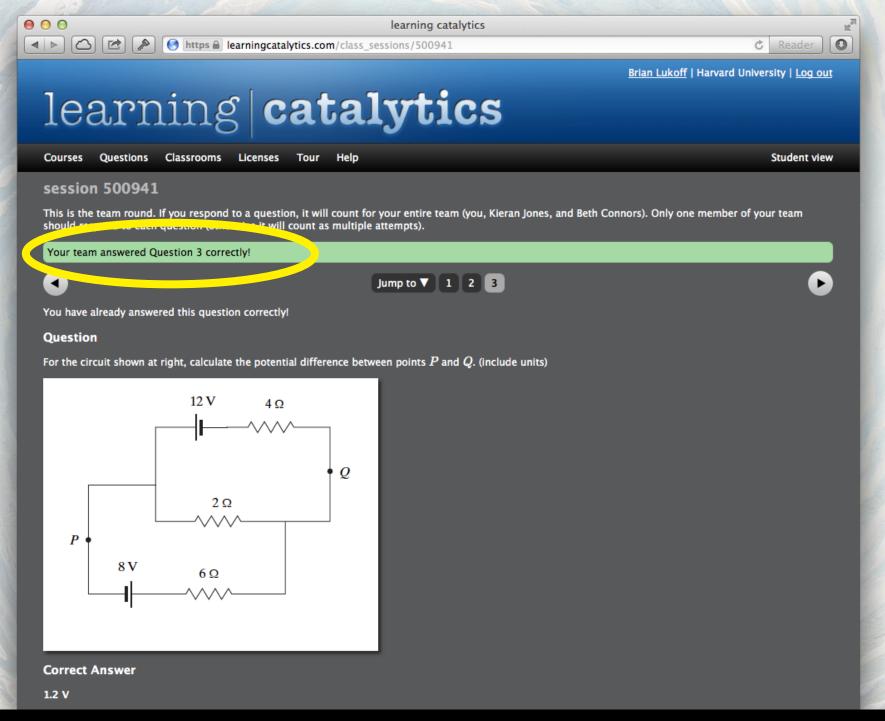




This is the team round. If you respond to a question, it will count for your entire team should respond to each question (otherwise it will count as multiple attempts).

Sorry, your response to Question 3 was not correct. You can attempt this question 2

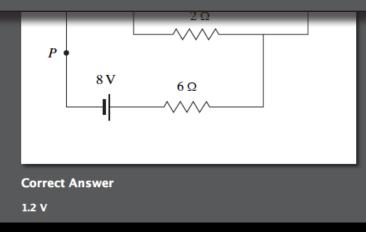


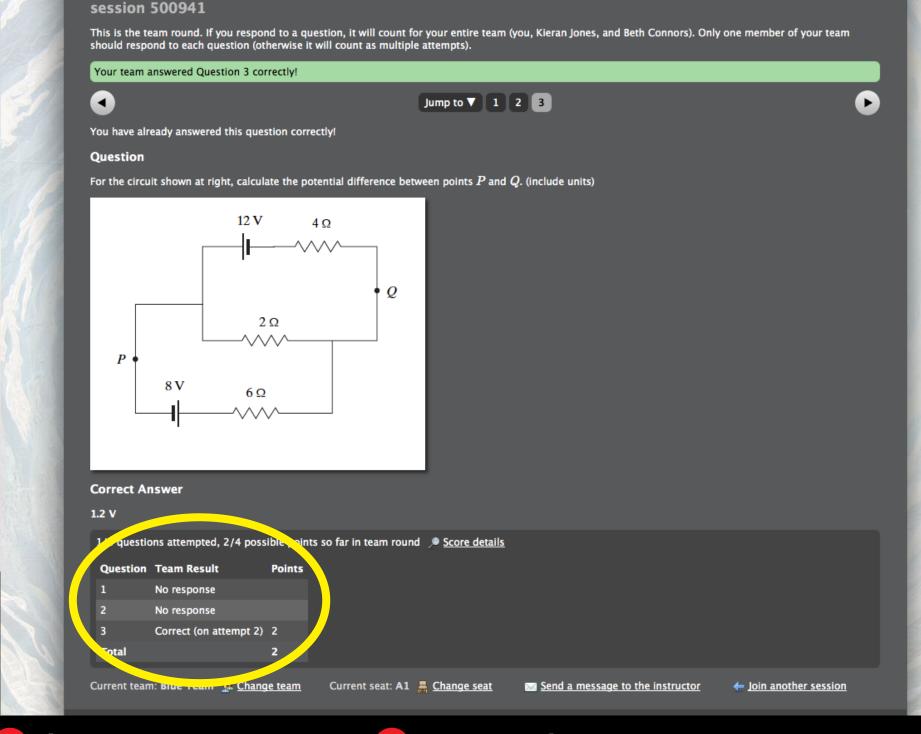


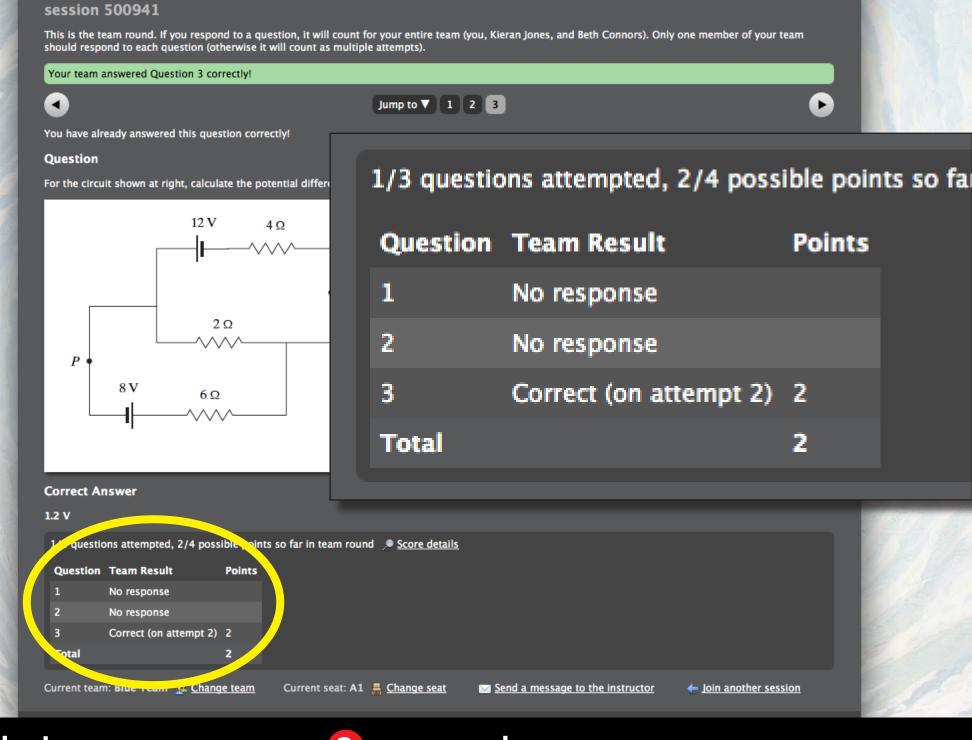


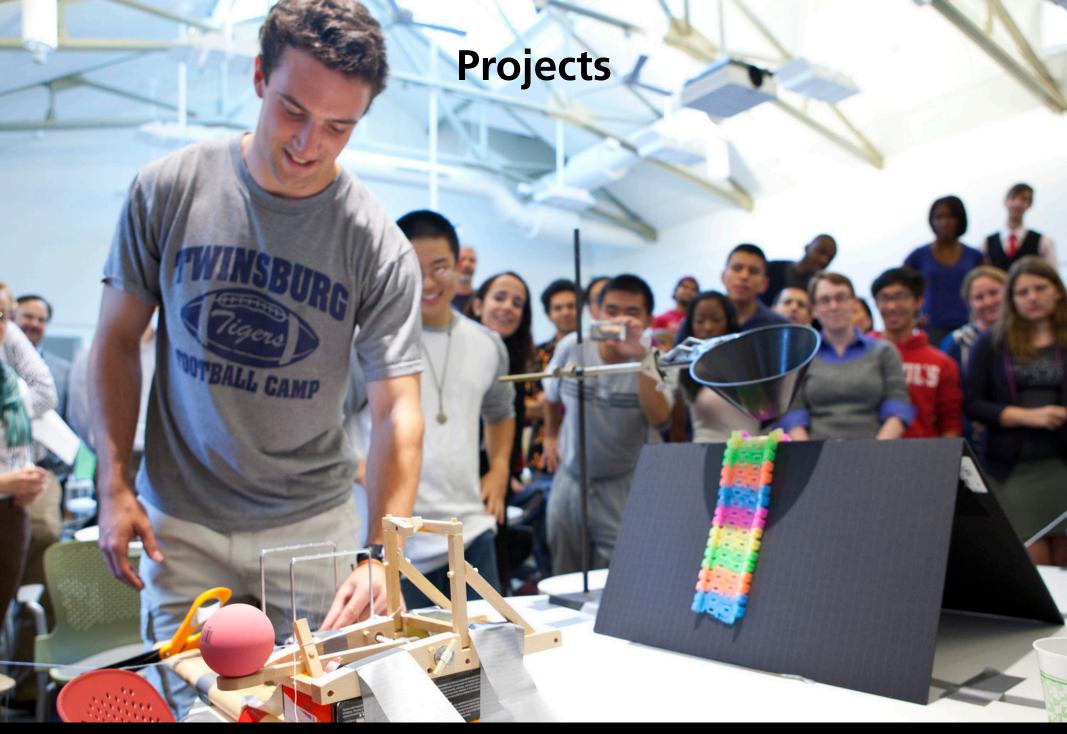
This is the team round. If you respond to a question, it will count for your entire team should respond to each question (otherwise it will count as multiple attempts).

Your team answered Question 3 correctly!









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"

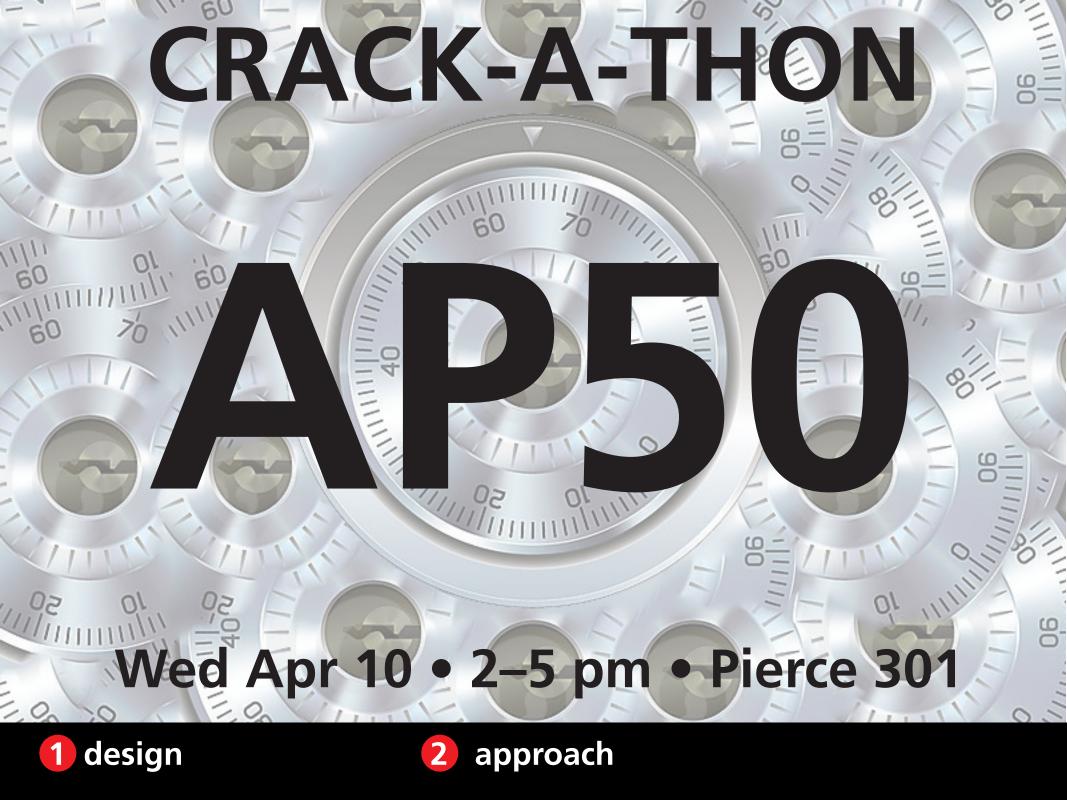


Projects

To be successful, the projects must

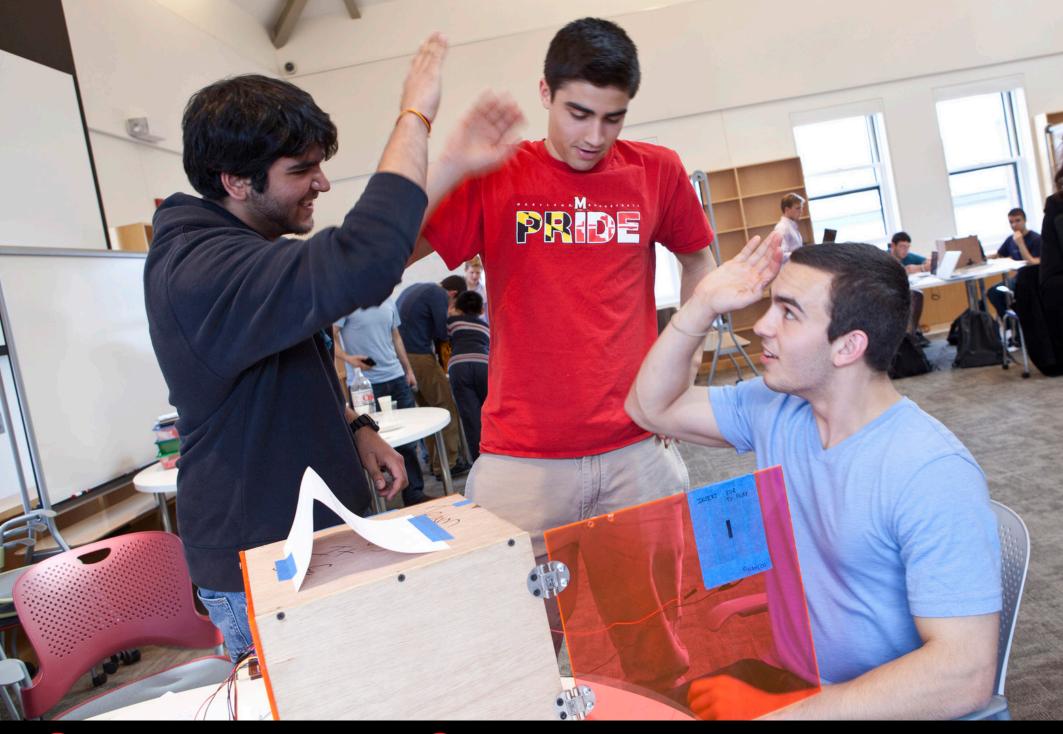
- require practical application of skills
- be linked to real world problems
- have compelling narrative (help/do good)













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								





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

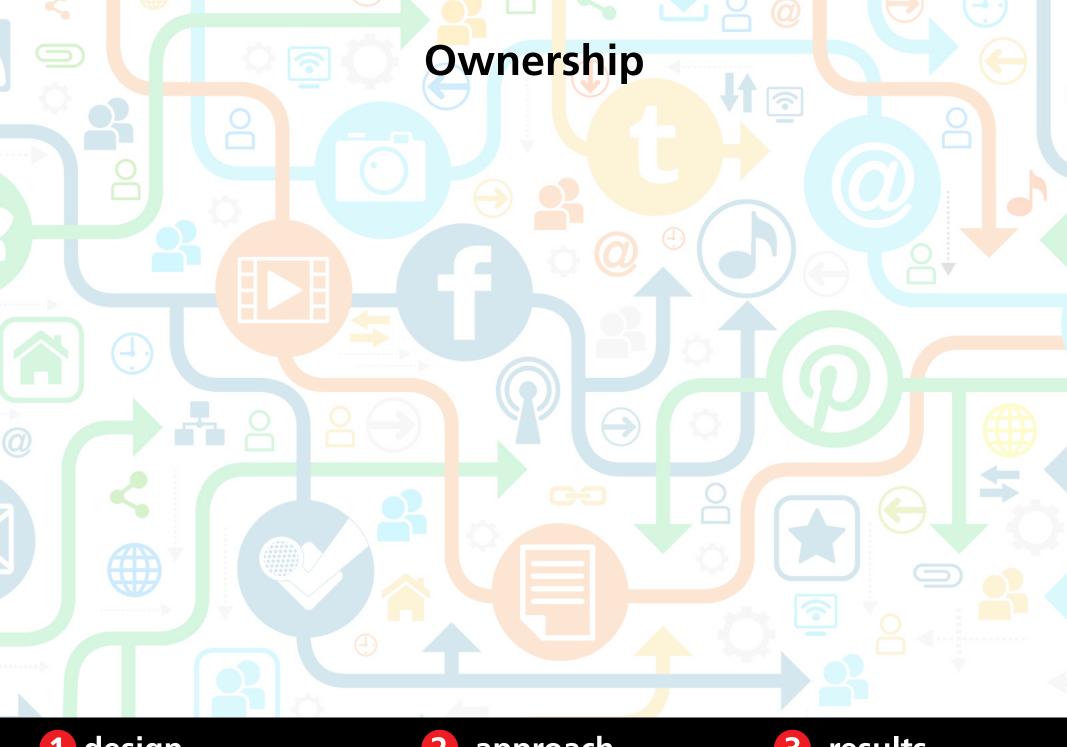
Assessment

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



approach

results

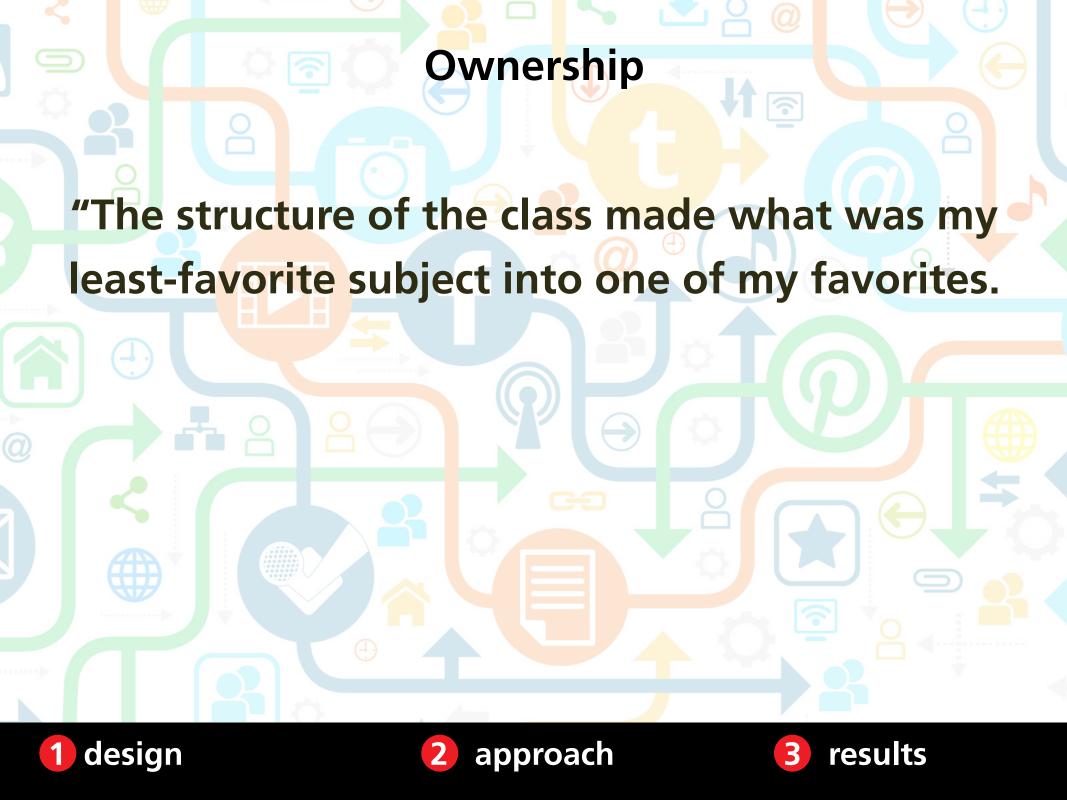


2 approach

results



approach



Ownership

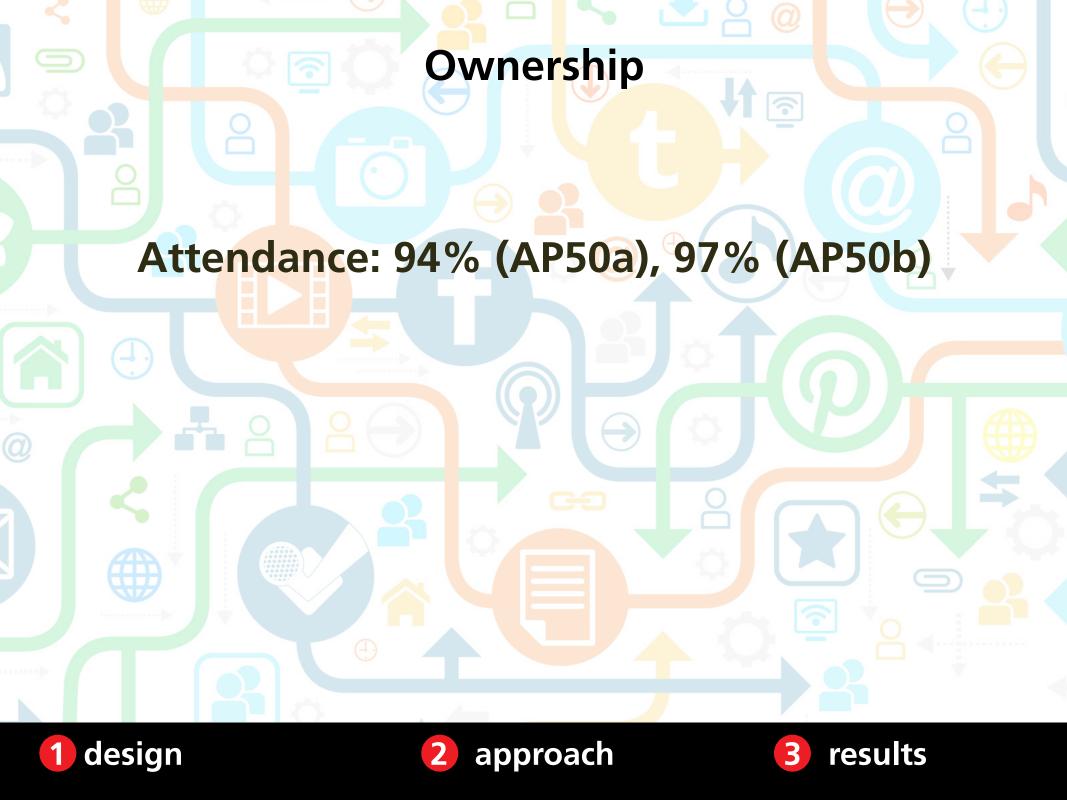
"The structure of the class made what was my least-favorite subject into one of my favorites. I was worried that people, including myself, would just slack off and do the bare minimum, but you really need to be on top of your readings and concepts in order to contribute to your team. GREAT CLASS!!!!!!"

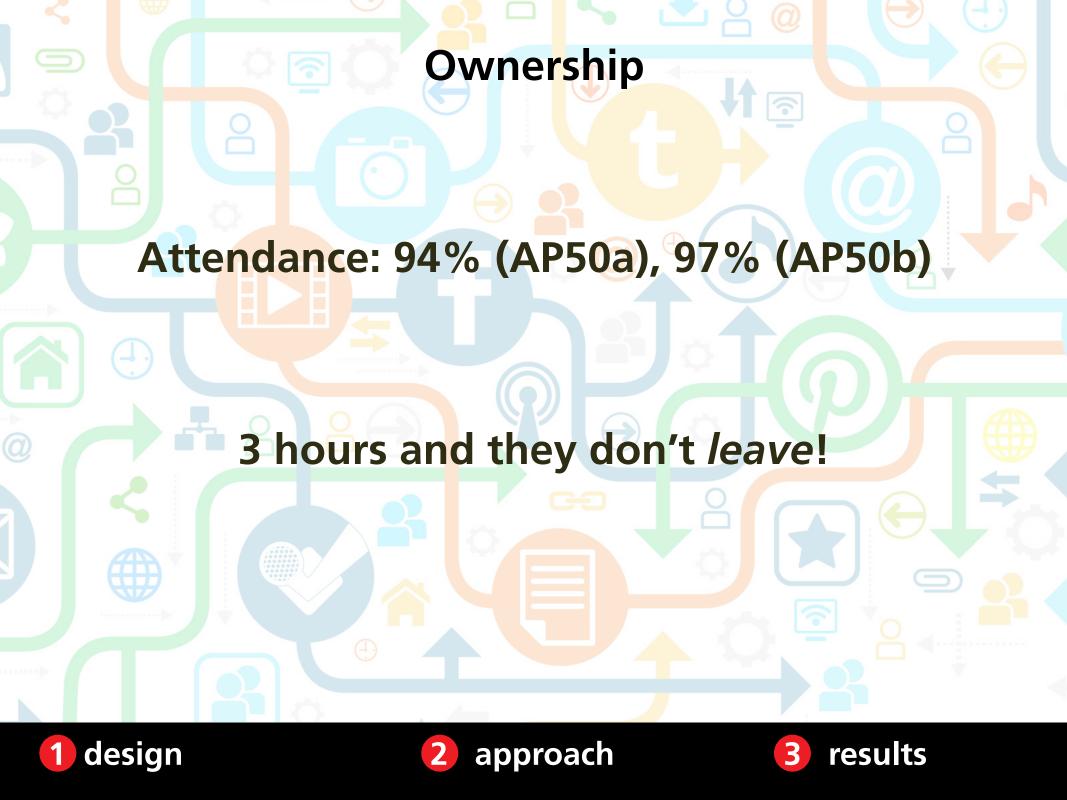


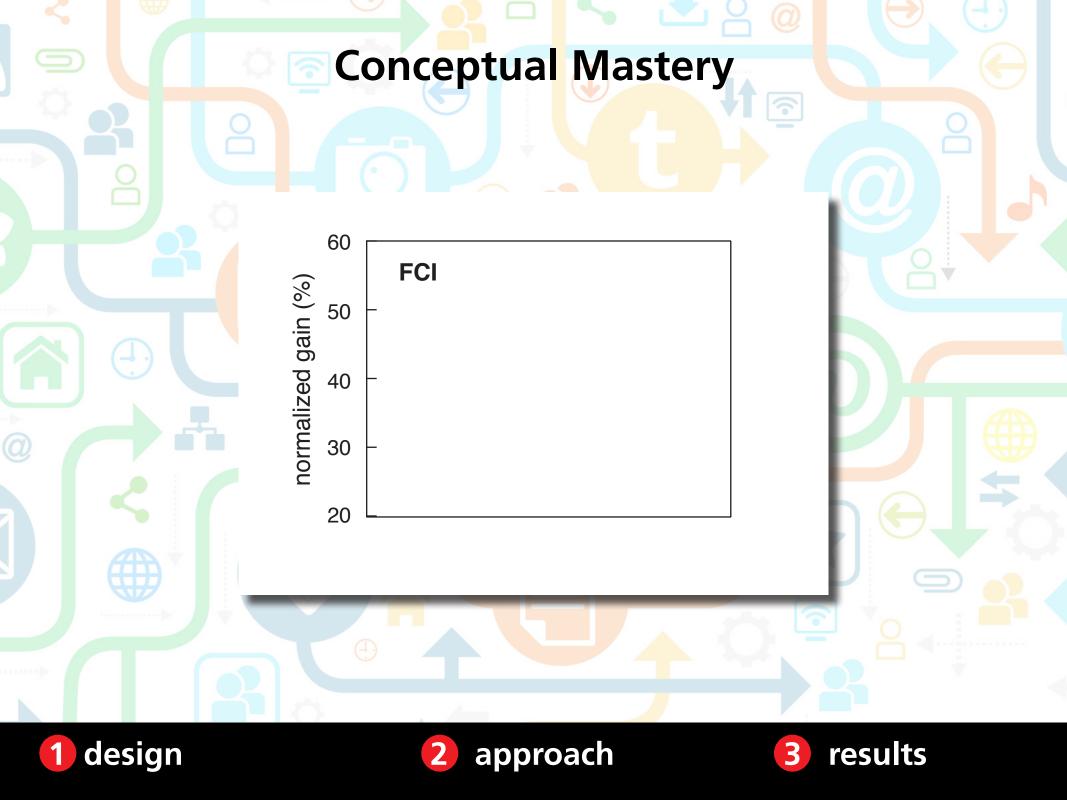


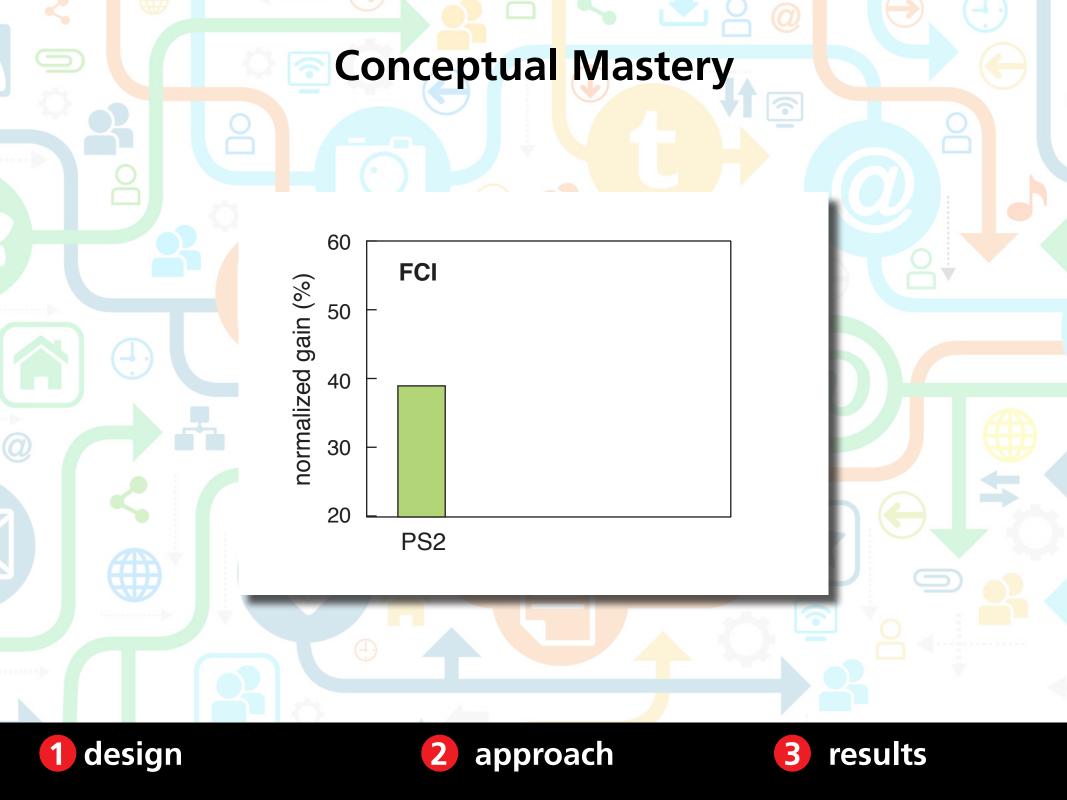
Ownership

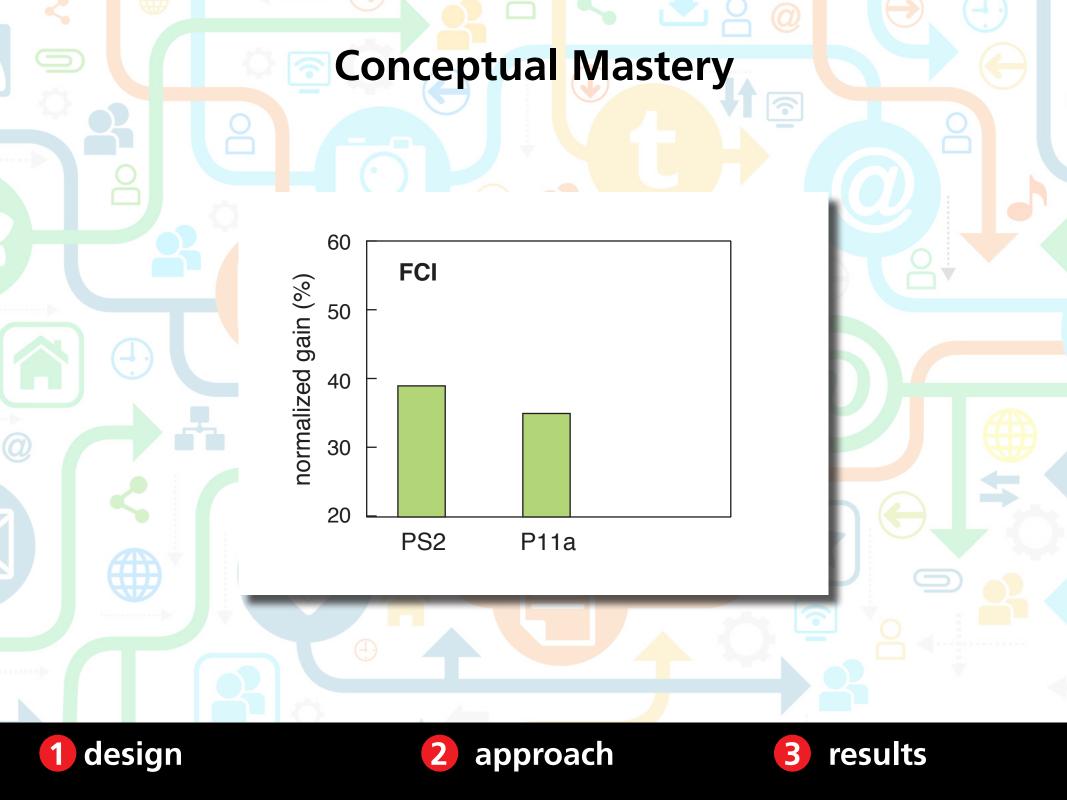
"Dear Harvard students, this class will be unlike any class you've taken at Harvard, and it will, hopefully, shift the entire foundation upon which you've based your education. I truly believe everyone should take this course; prepare to take full ownership of your learning."

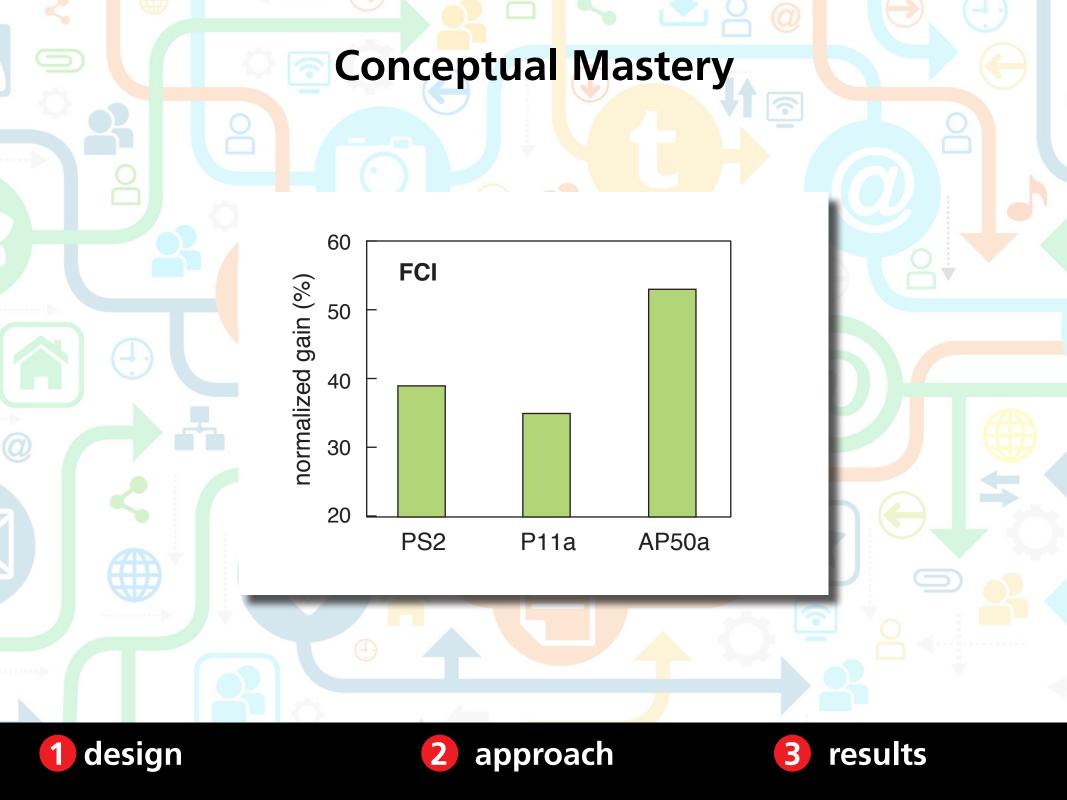


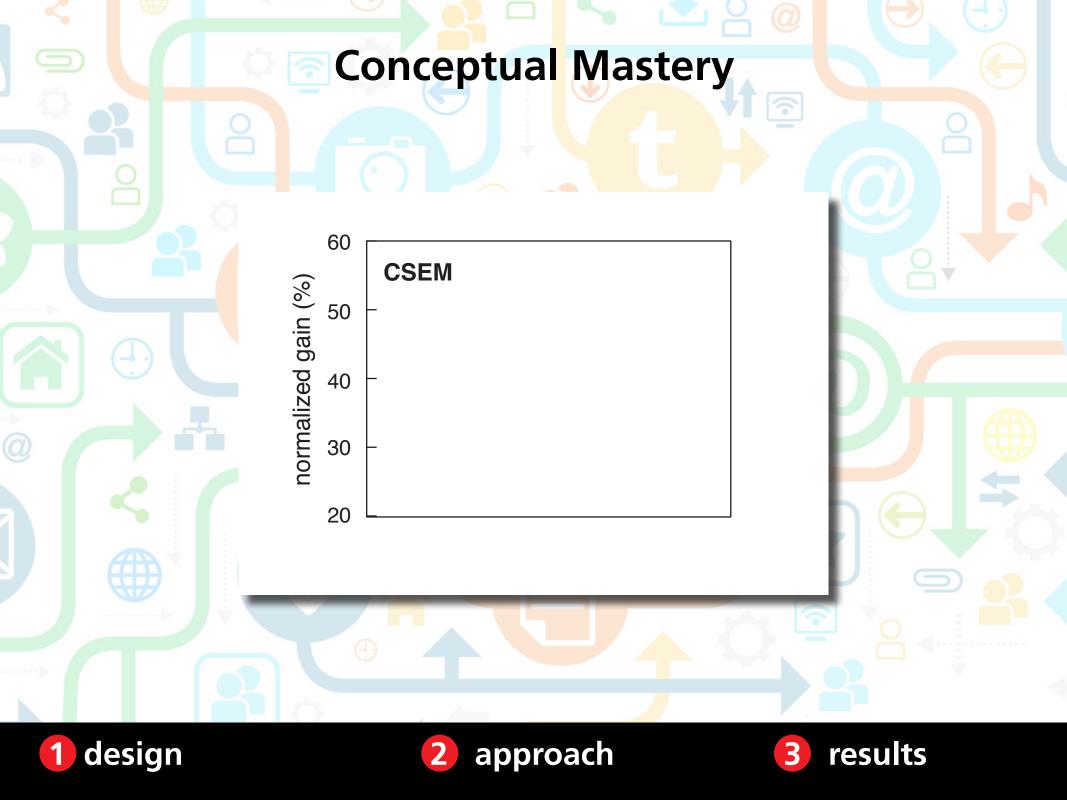


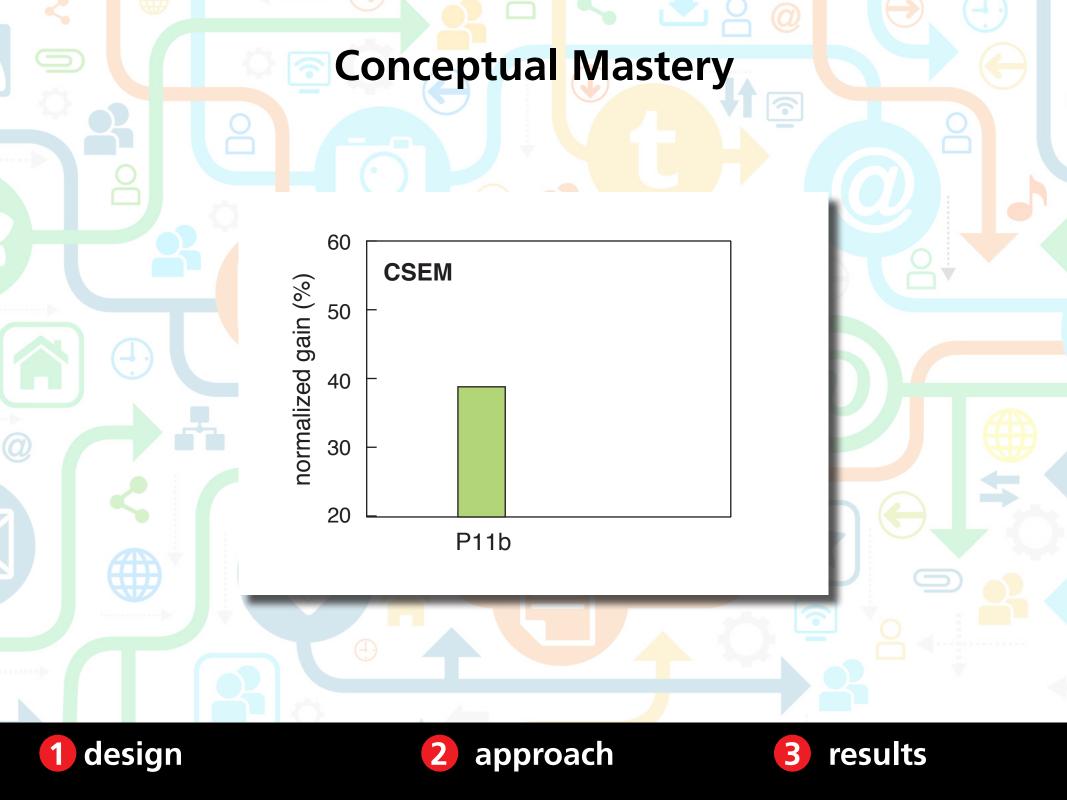


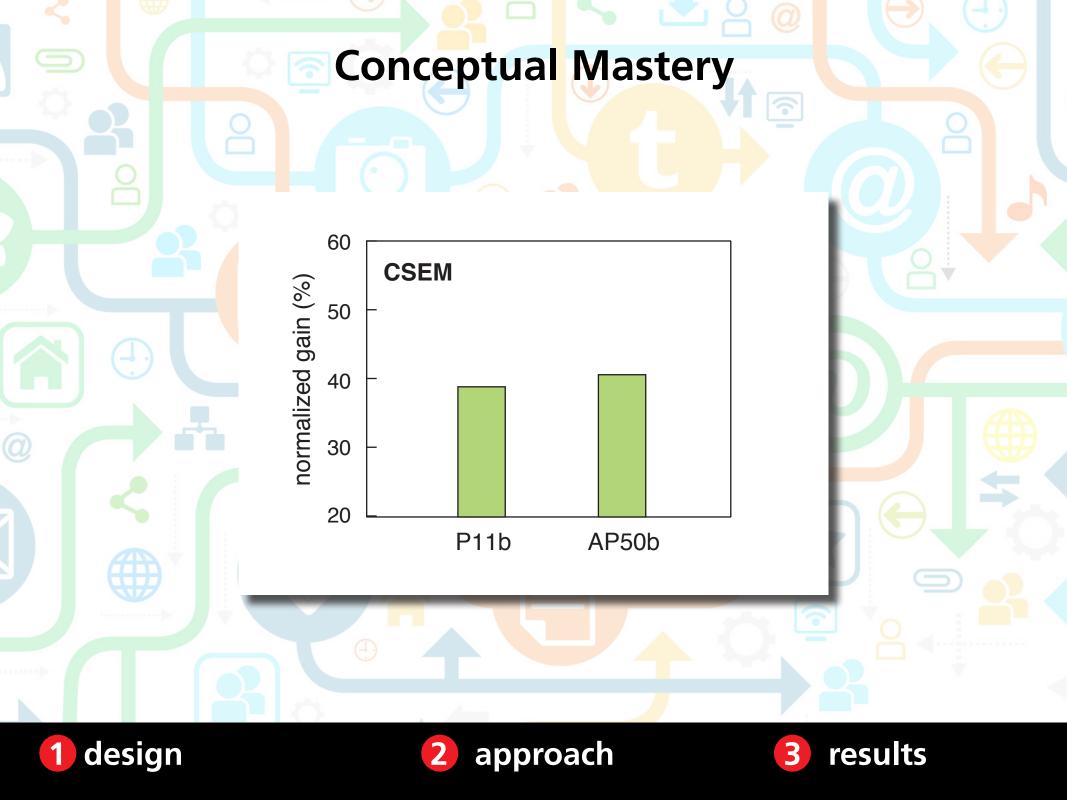














2 approach

3 results







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

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

and the students pioneers in AP50!



Google

Google Search

I'm Feeling Lucky

Google

mazur

Google Search

I'm Feeling Lucky



mazur

Google Search (I'm Feeling Lucky



mazur

Google Search I'm Feeling Lucky

