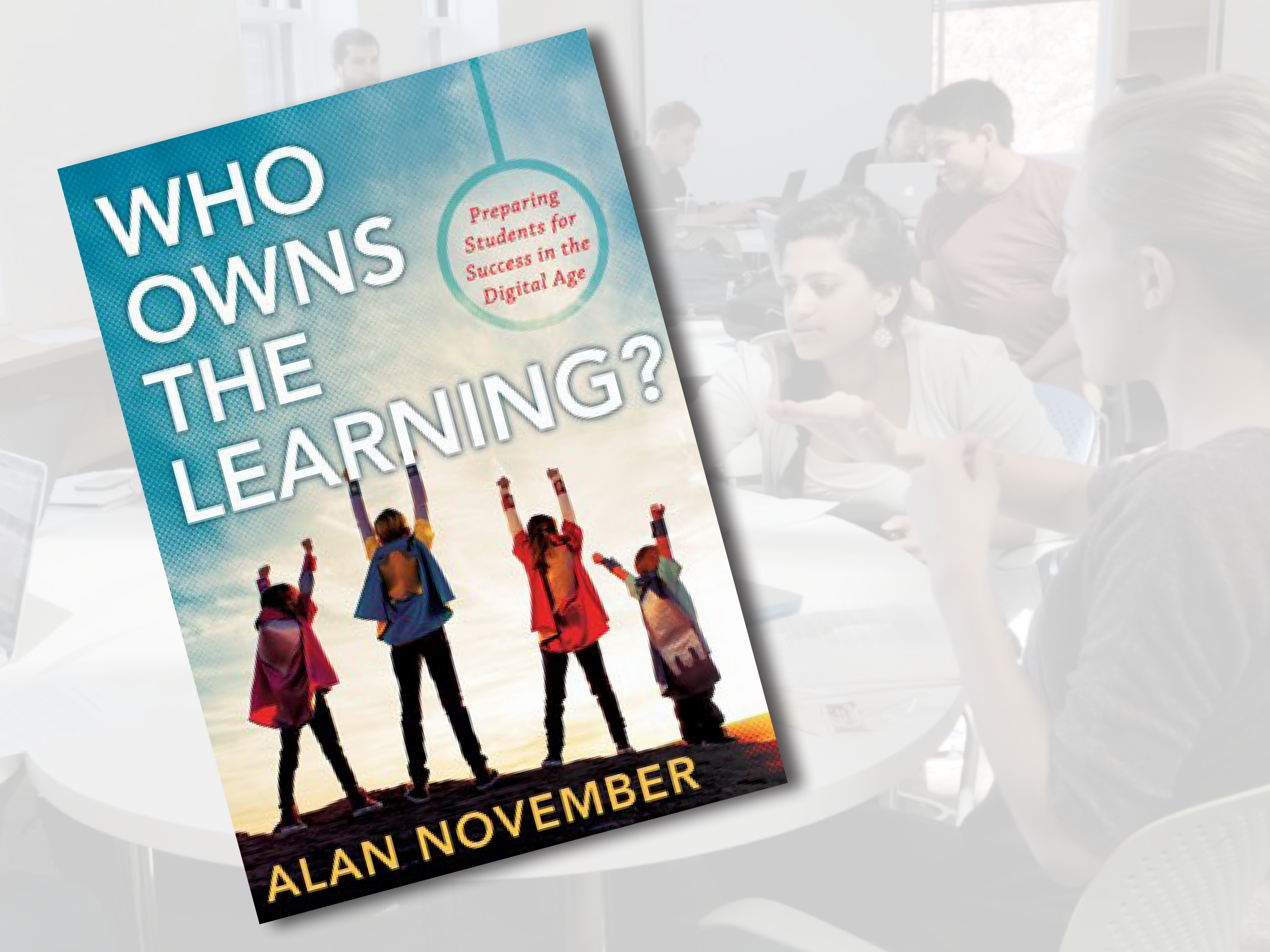
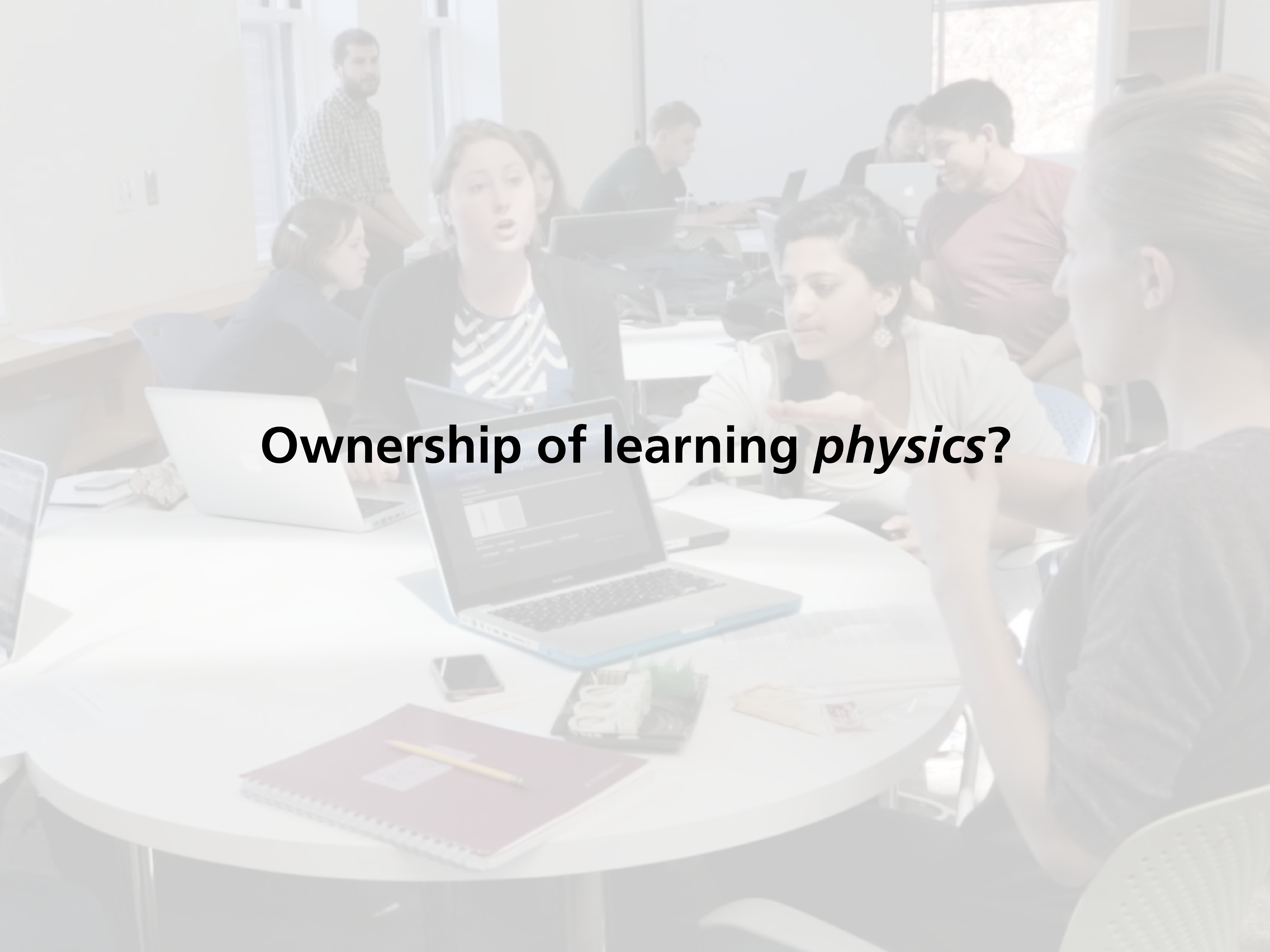
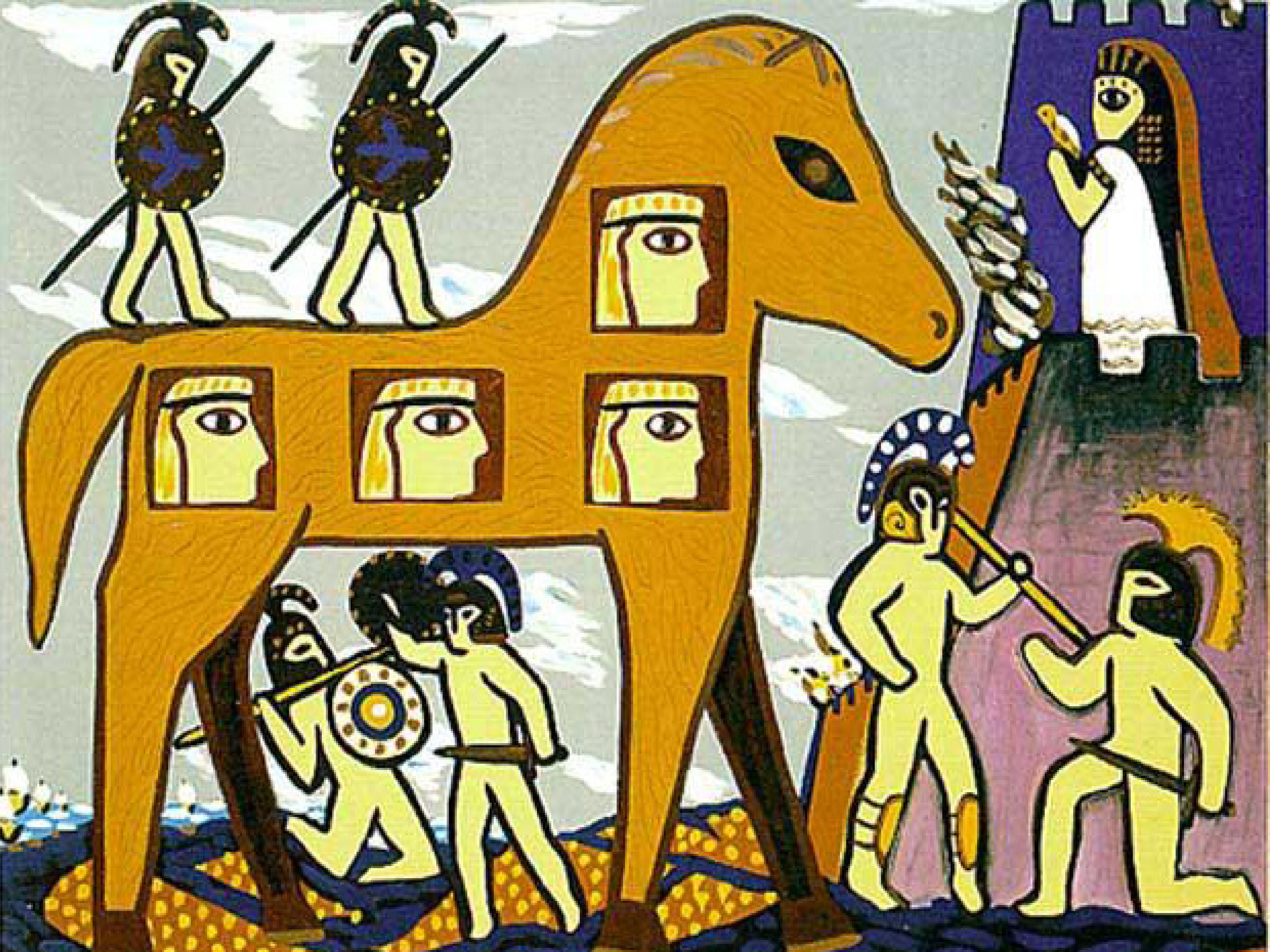
AP50: A team-based, project-based approach to teaching introductory physics

Harvard University
Cambridge, MA, 9 September 2013


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



Ownership of learning *physics*?

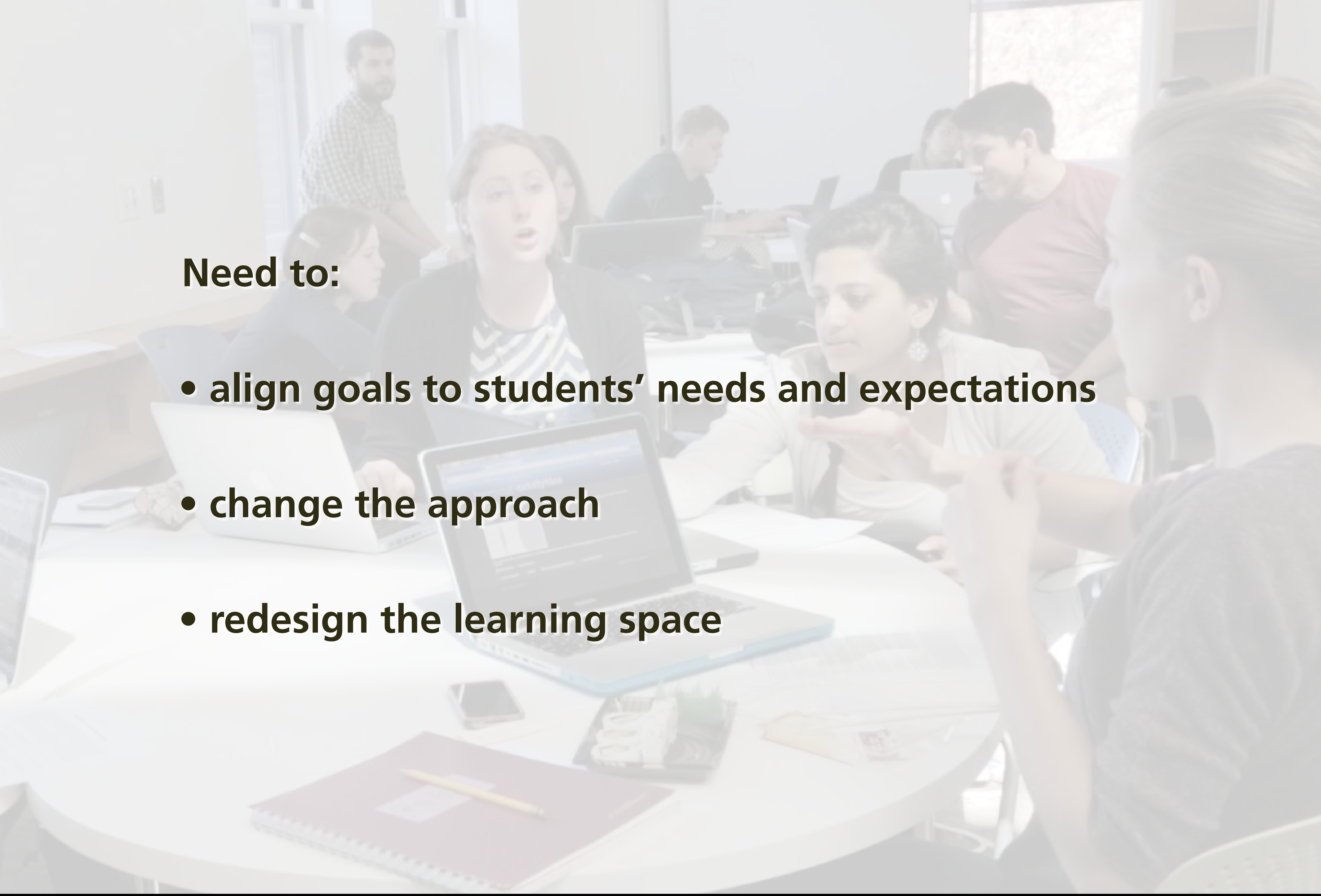


team & project-based approach

1 design

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

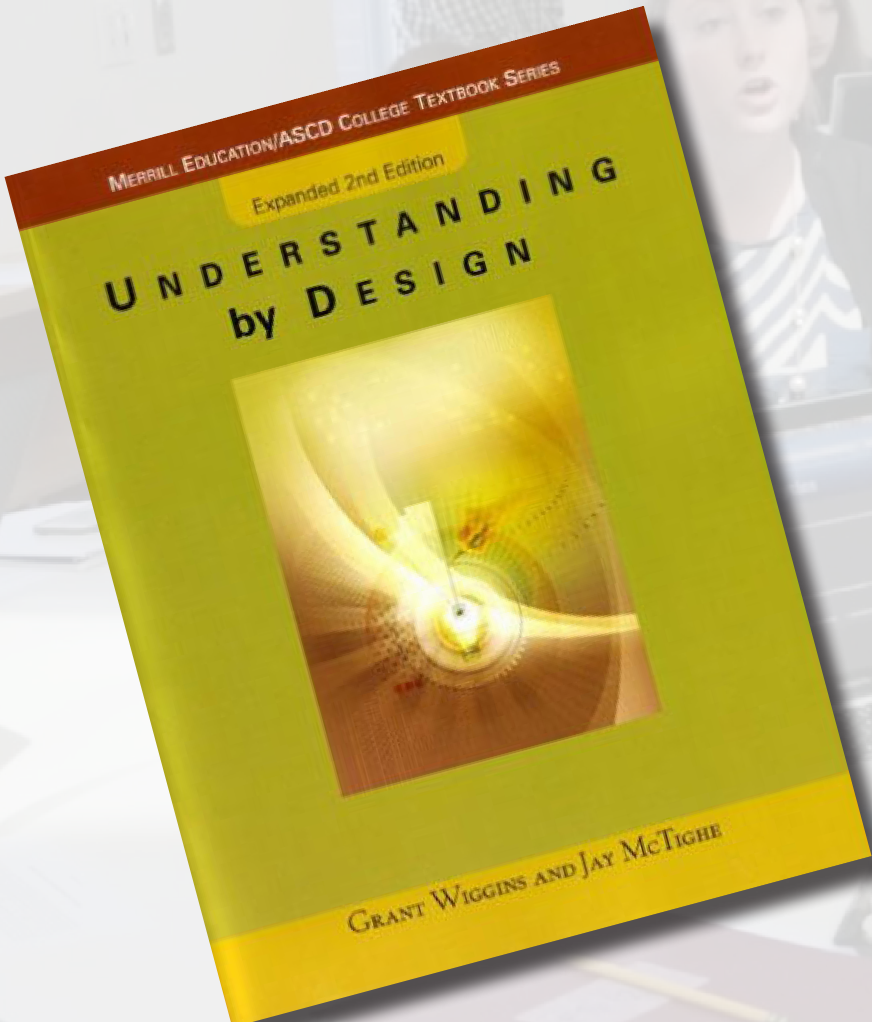
1 design 2 approach 3 results



Need to:

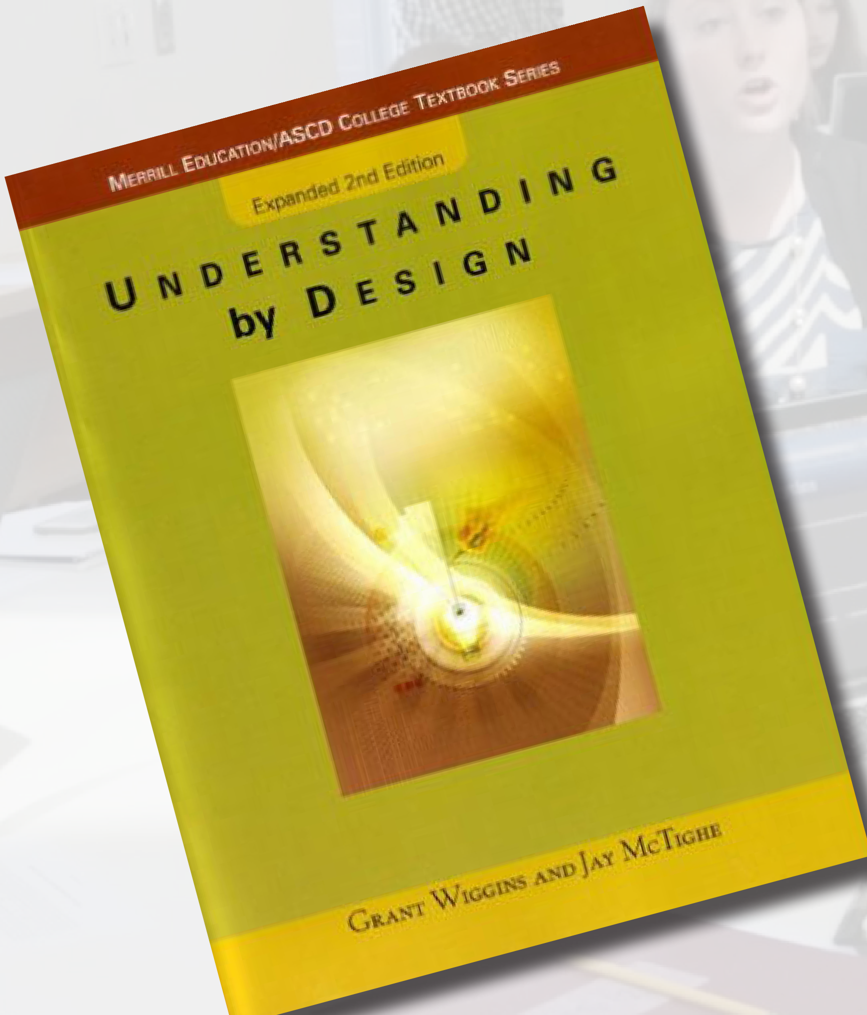
- align goals to students' needs and expectations
- change the approach
- redesign the learning space

Setting learning goals



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

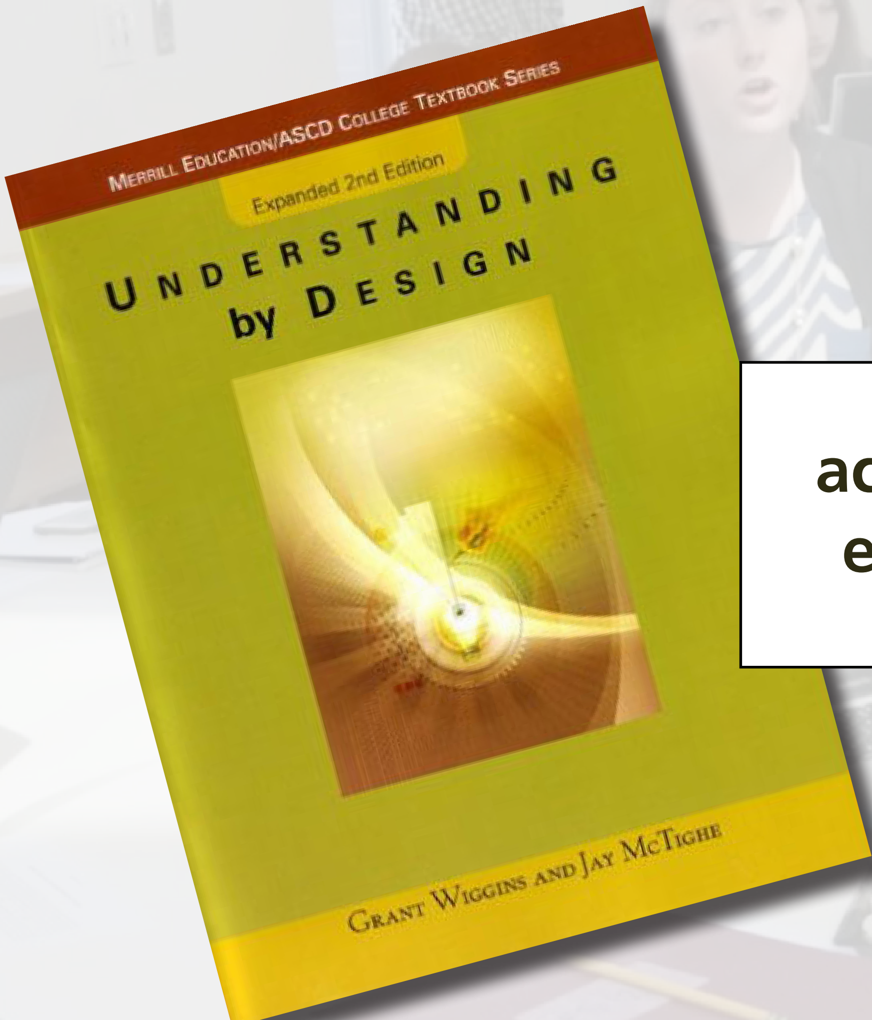
Backward design



desired outcomes

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

Backward design



acceptable evidence	◀	desired outcomes

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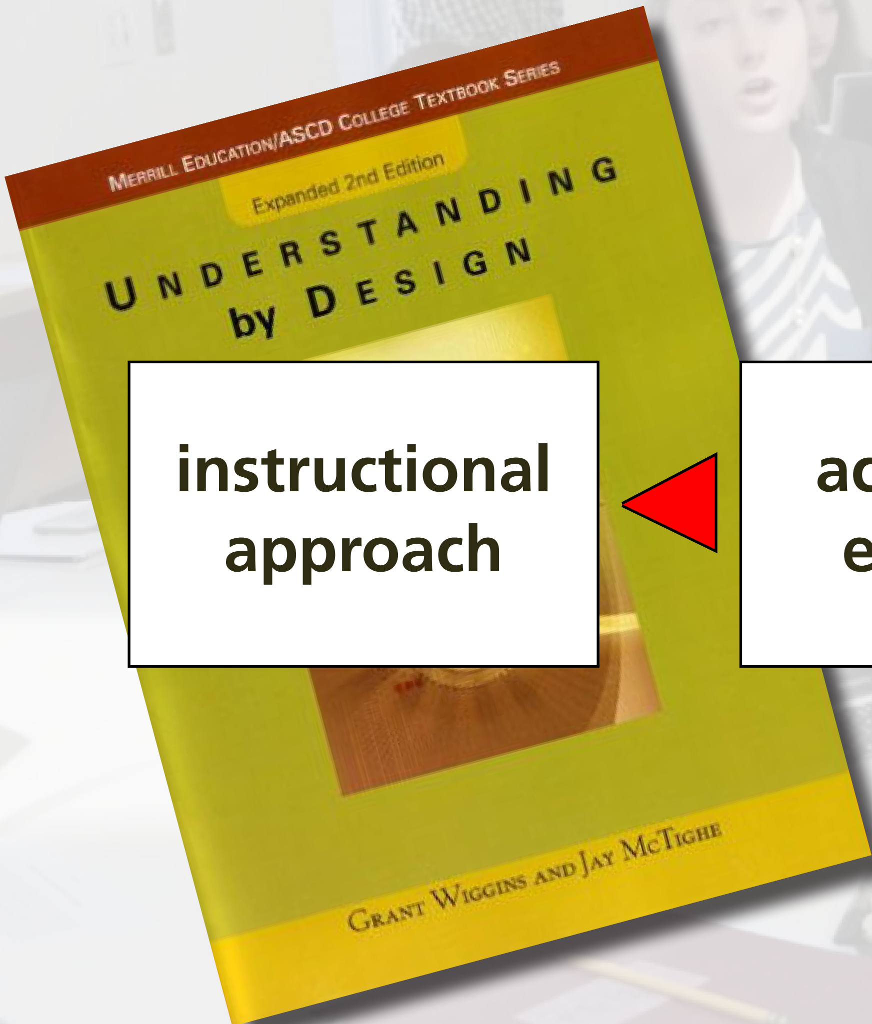
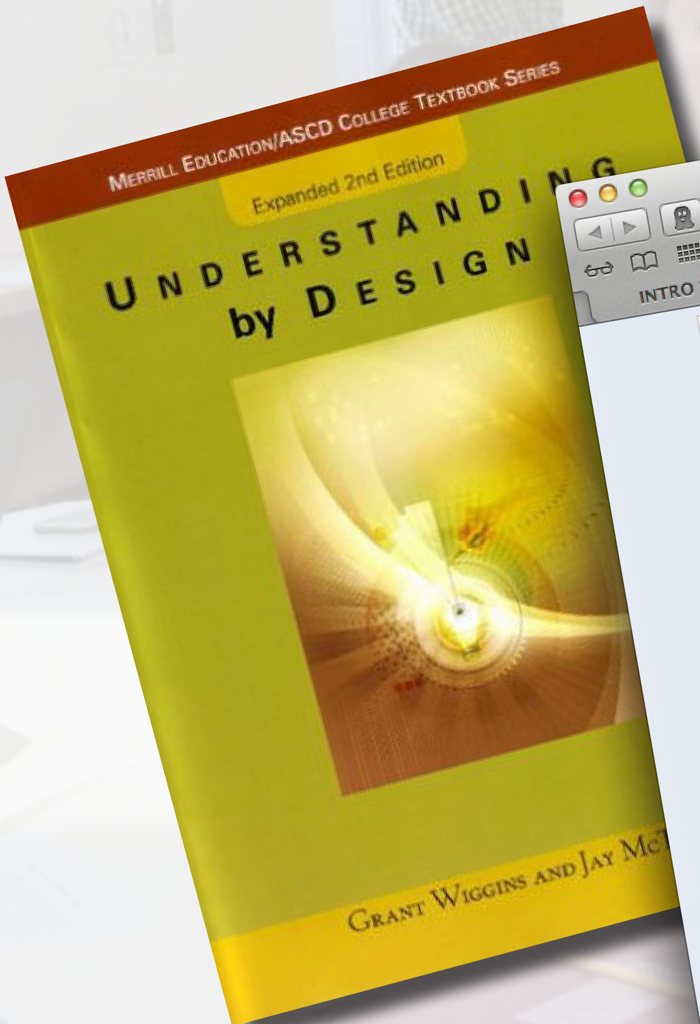
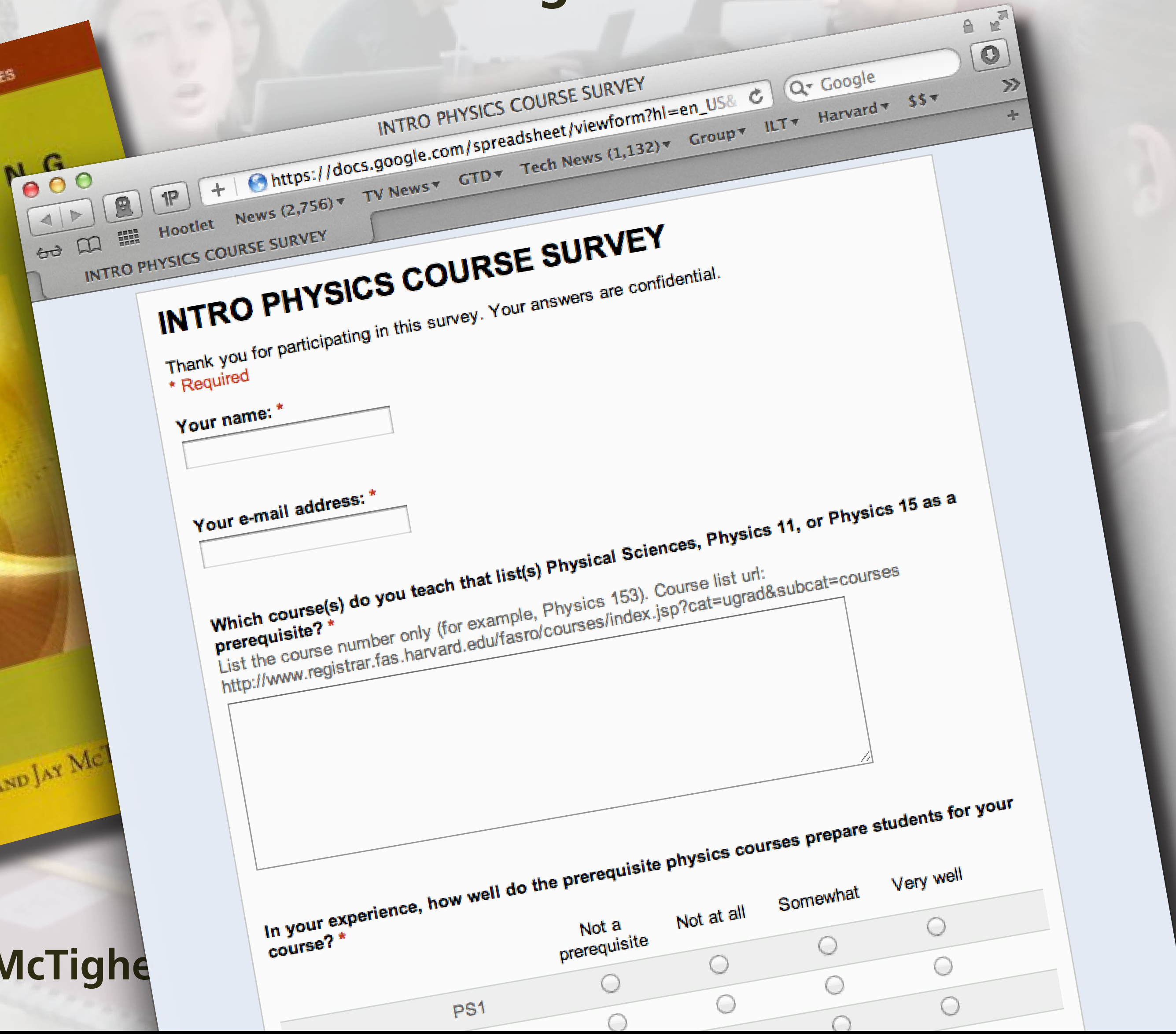


instructional approach ◀ acceptable evidence ◀ desired outcomes

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

Backward design





Grant Wiggins and Jay McTighe

competencies

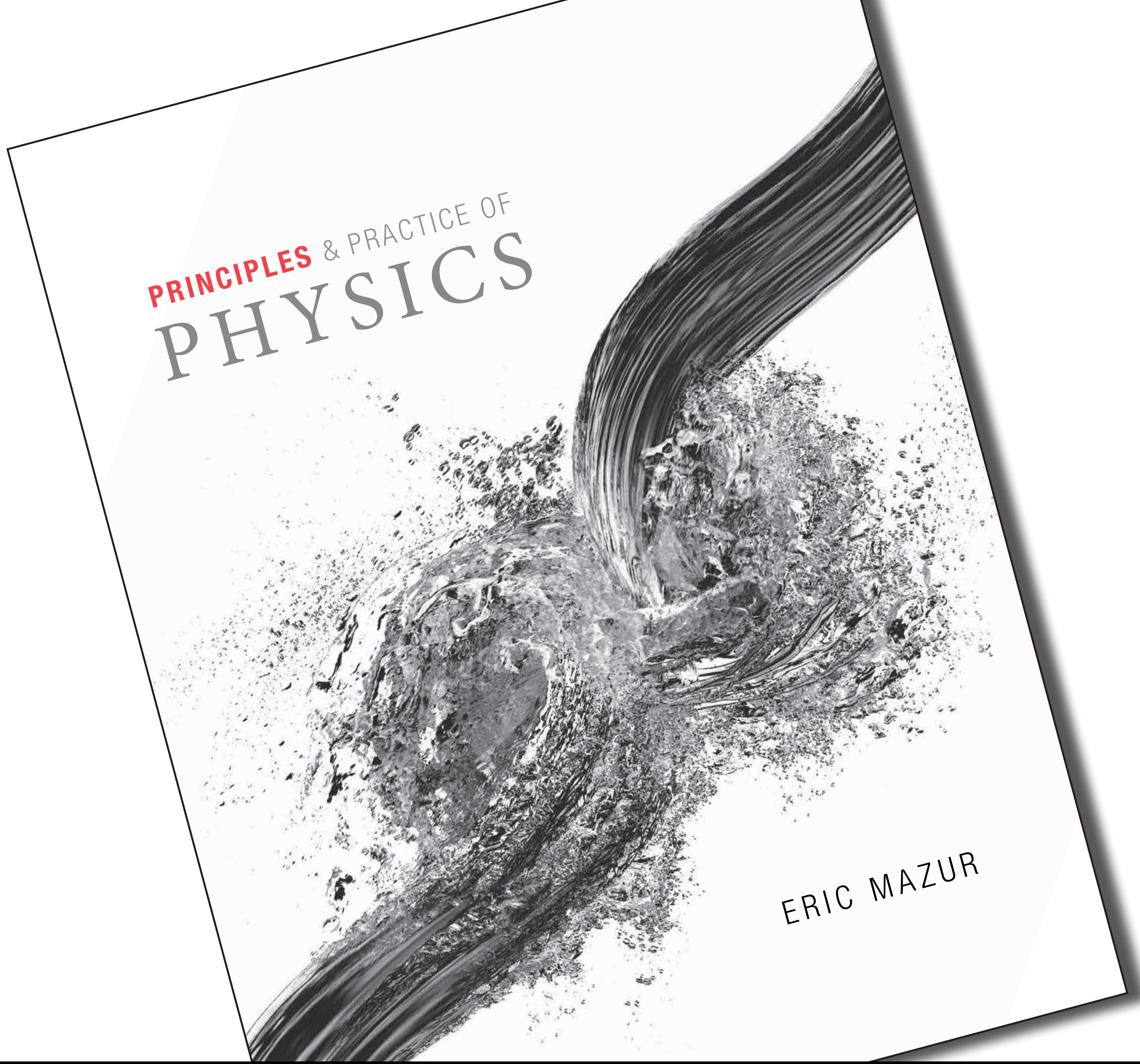
course goals

COURSE GOALS

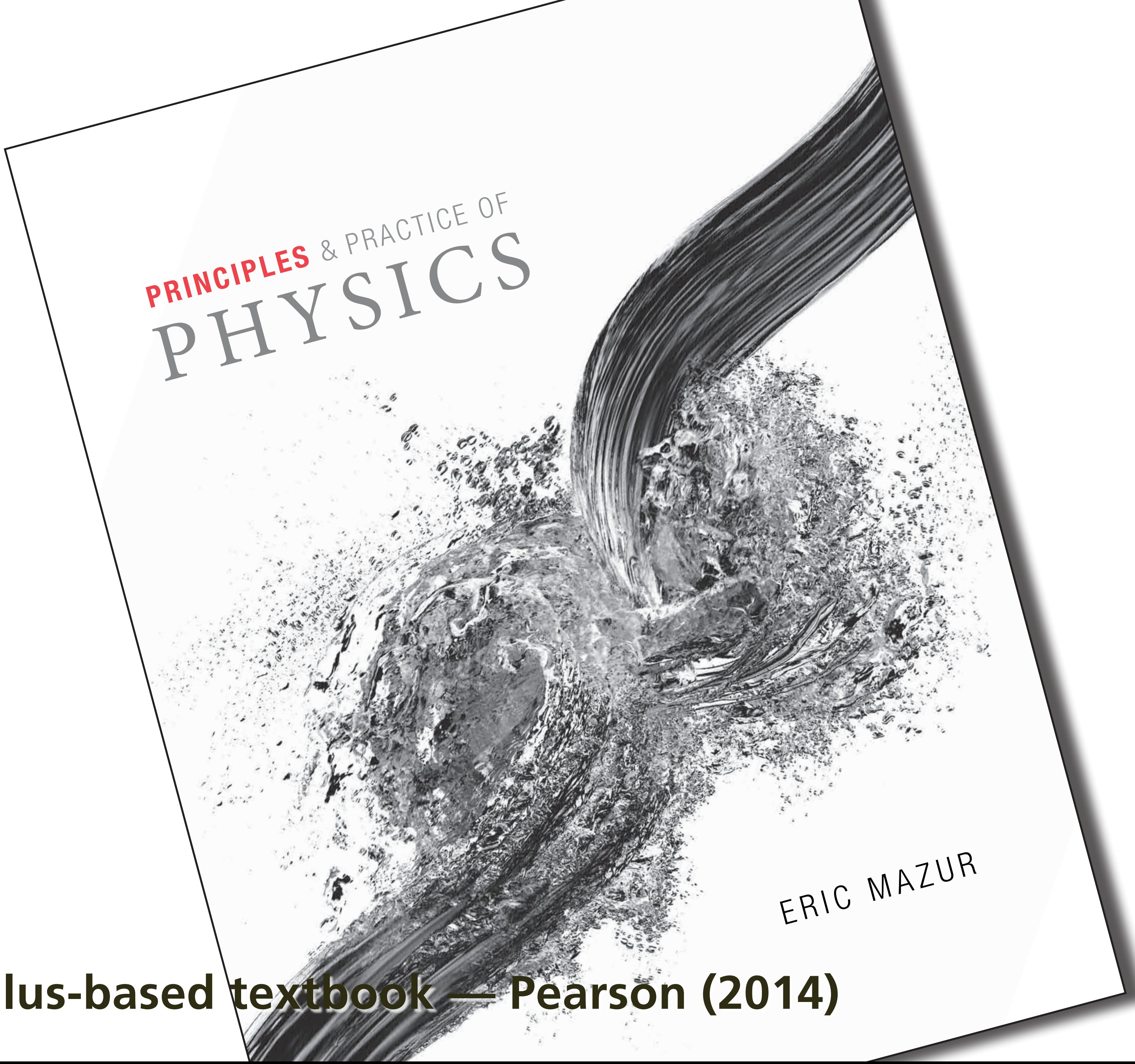
After successful completion of this course, you will be able to… (with…

- 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 order 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…
- …identify sources of uncertainty, and minimiz… …easurement in order to develo… …ts and presentat…

content-specific goals



1 design



calculus-based textbook — Pearson (2014)

1 design

Content

Content

1 design

1 design

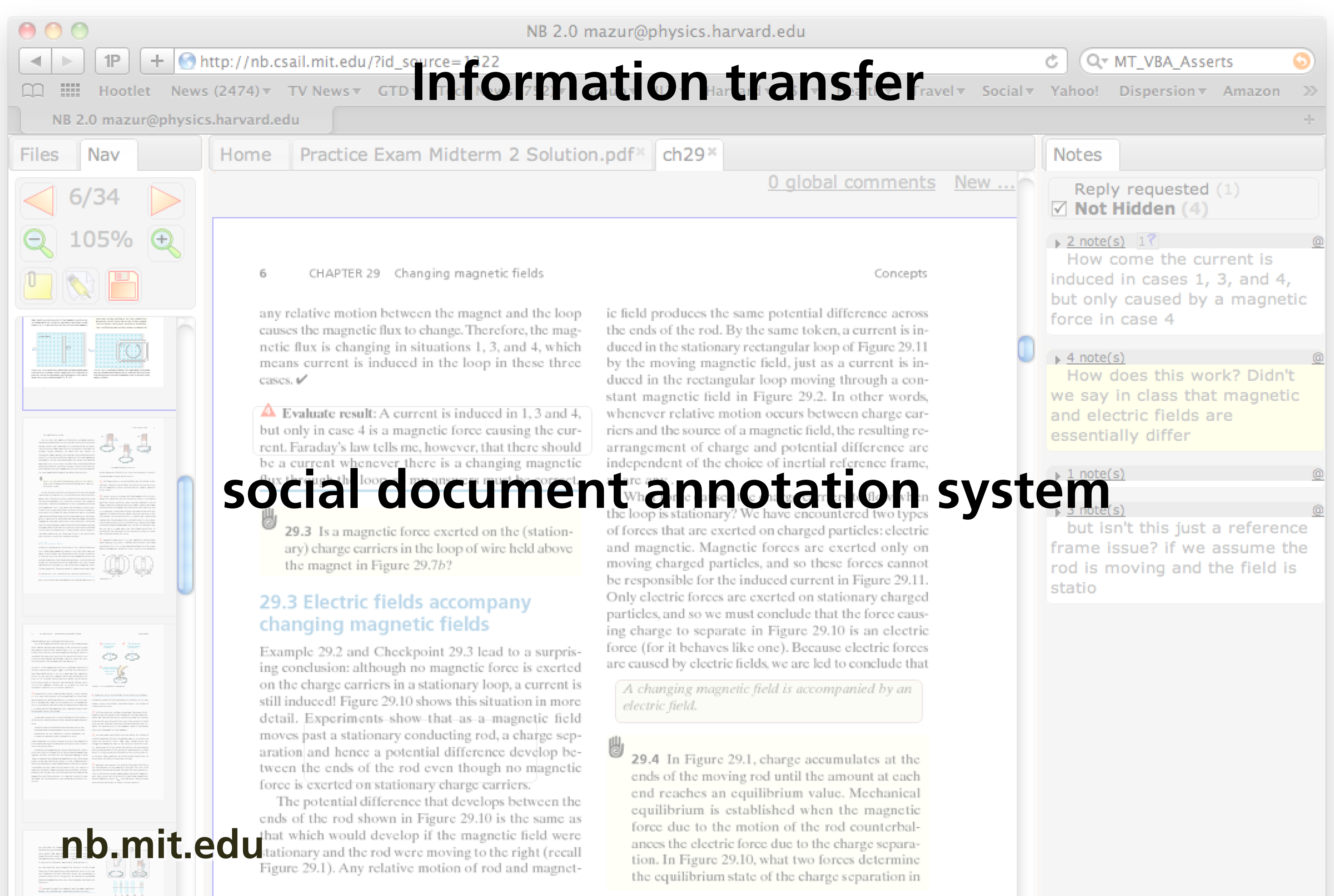
2 approach

1 design 2 approach

Three major components:

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

Information transfer



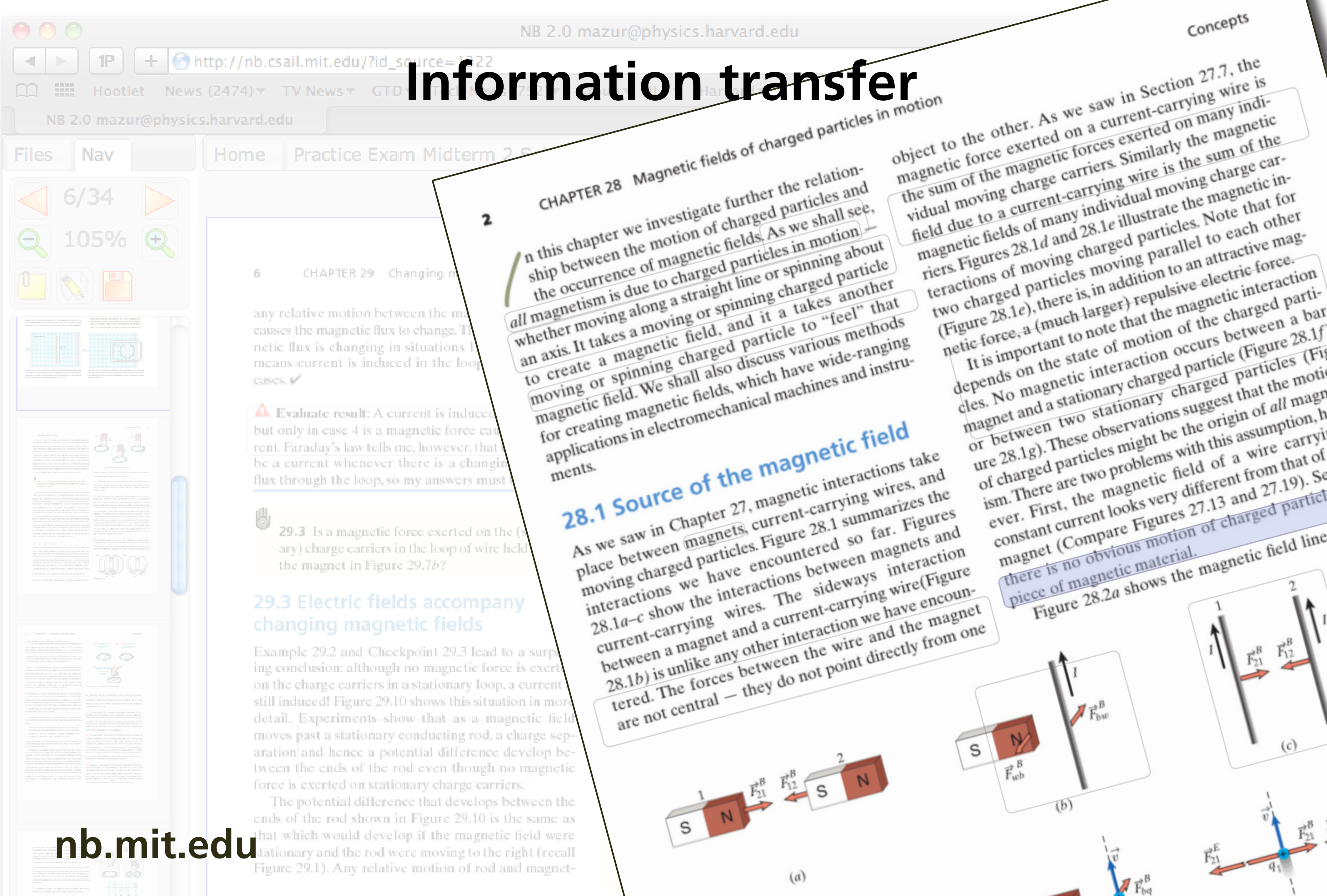
social document annotation system

nb.mit.edu

1 design

2 approach

Information transfer



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1 design

2 approach

Information transfer

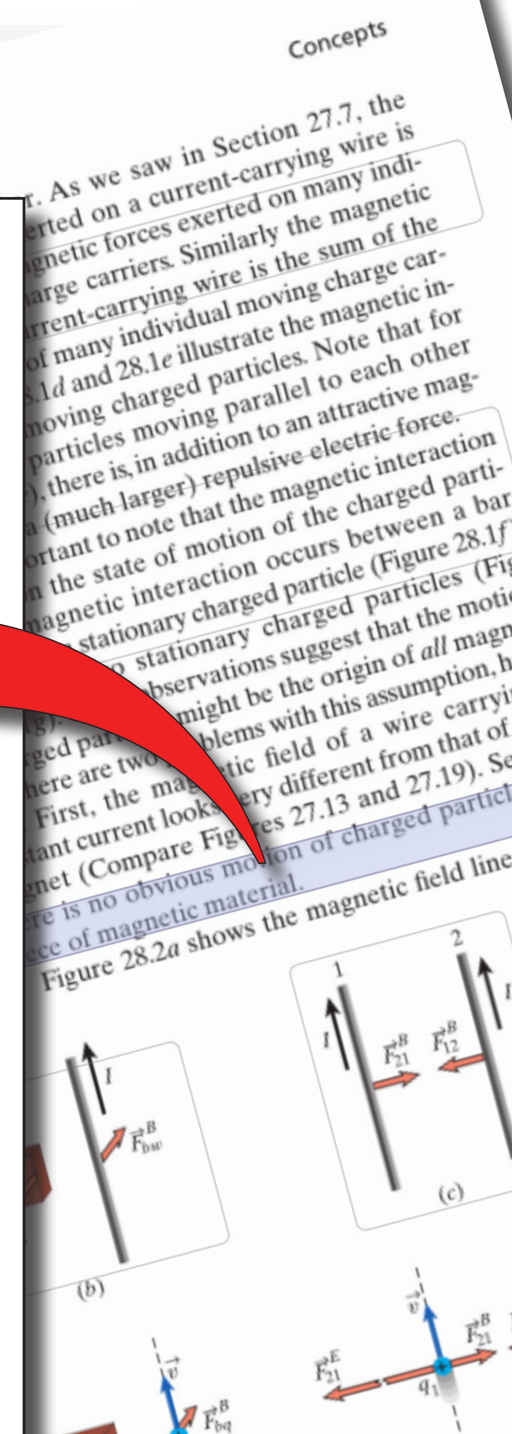
Student 1 – 25 Feb, 04:55PM
Yeah, this is where I'm confused. From the first paragraph: "It takes a moving or spinning charged particle to create a magnetic field..." however there is no obvious motion of charged particles in a piece of magnetic material (bar magnet for example?). How does this reconcile?

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 ... 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 ...



1 design   2 approach

Information transfer

over 1,000 annotations in one lecture!

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Student 4 – 4 Mar, 0 ... M
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1 design

2 approach

In-class activities

1 design

2 approach

In-class activities

2 weekly 3-hour class periods

In-class activities

blend of best practices

In-class activities

learning catalytics

estimation

tutorials

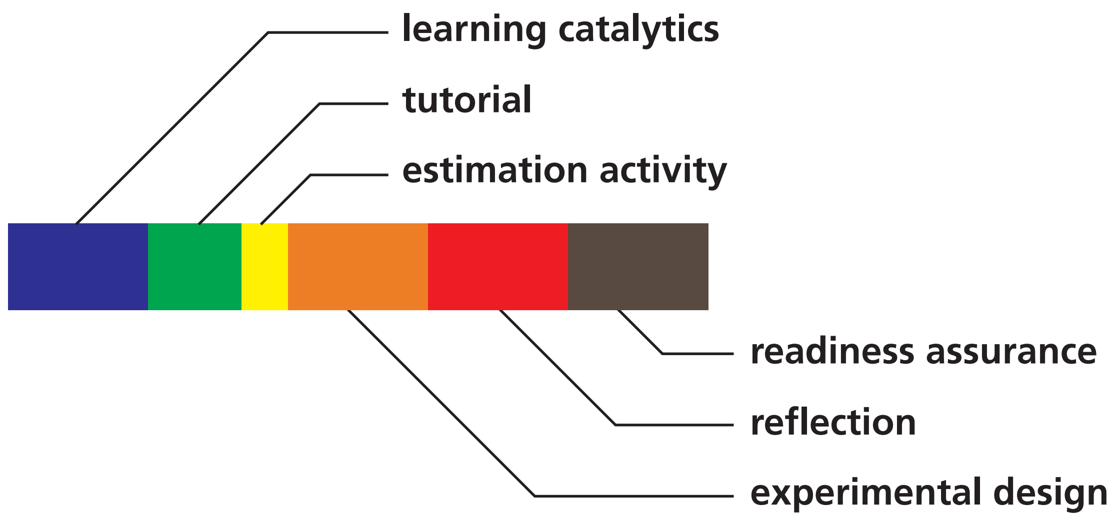
readiness assurance

blend of best practices

experimental design

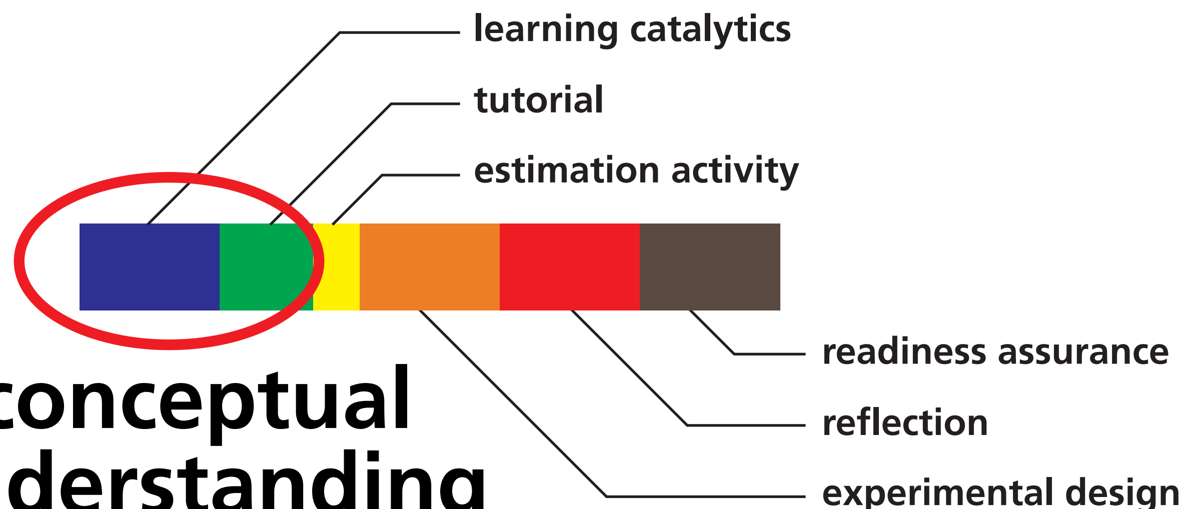
reflection

In-class activities



1 design
2 approach

In-class activities

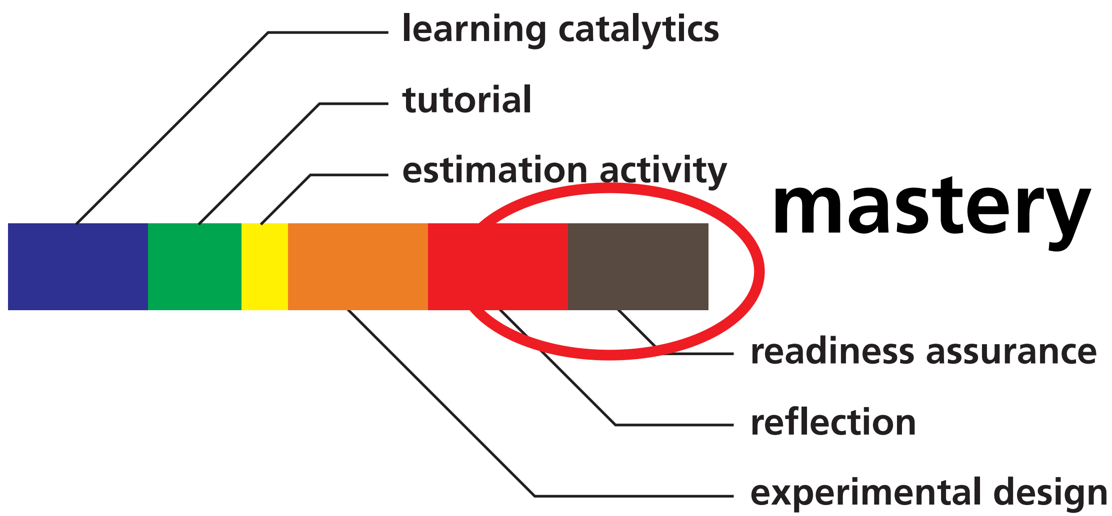


conceptual understanding

1 design

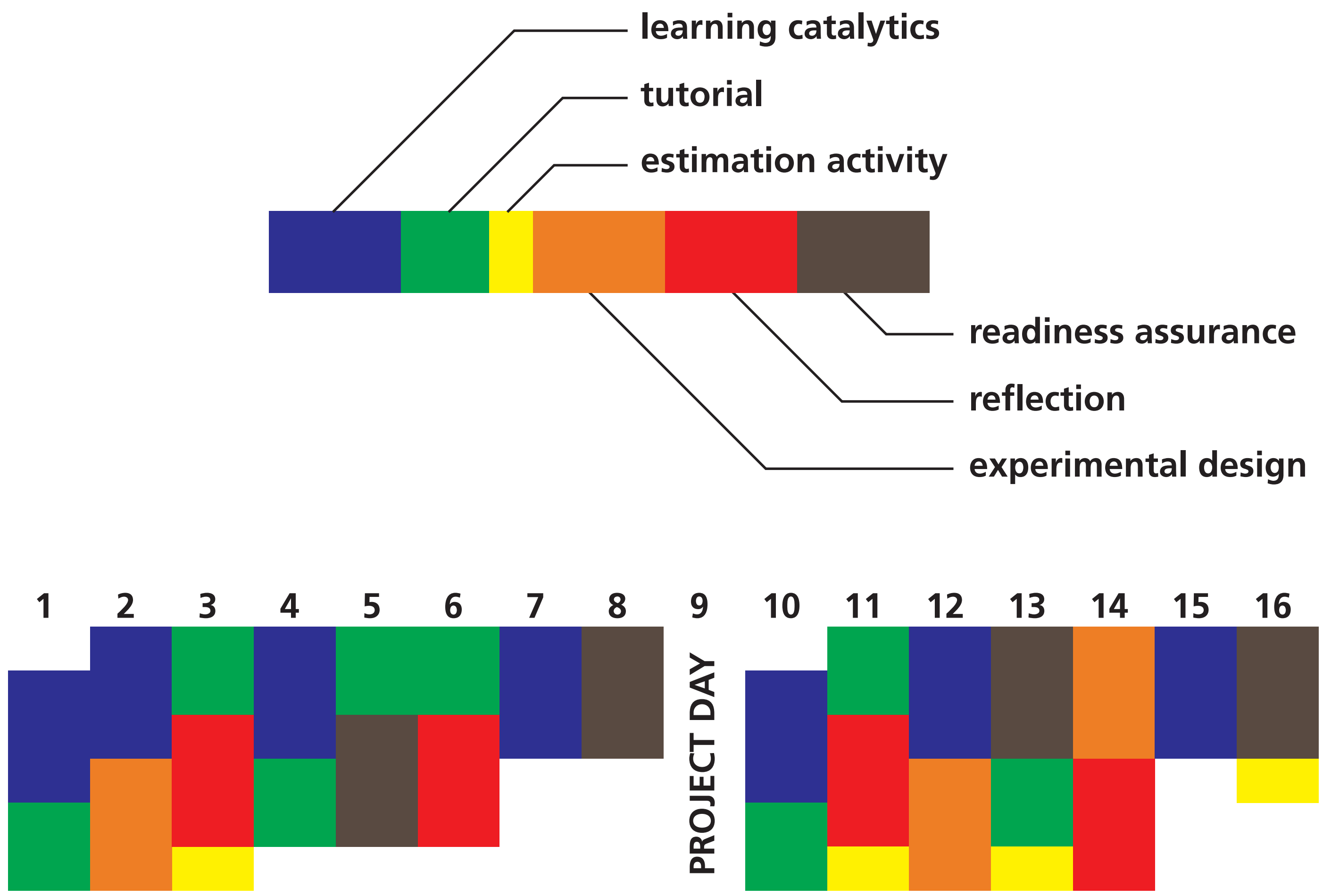
2 approach

In-class activities



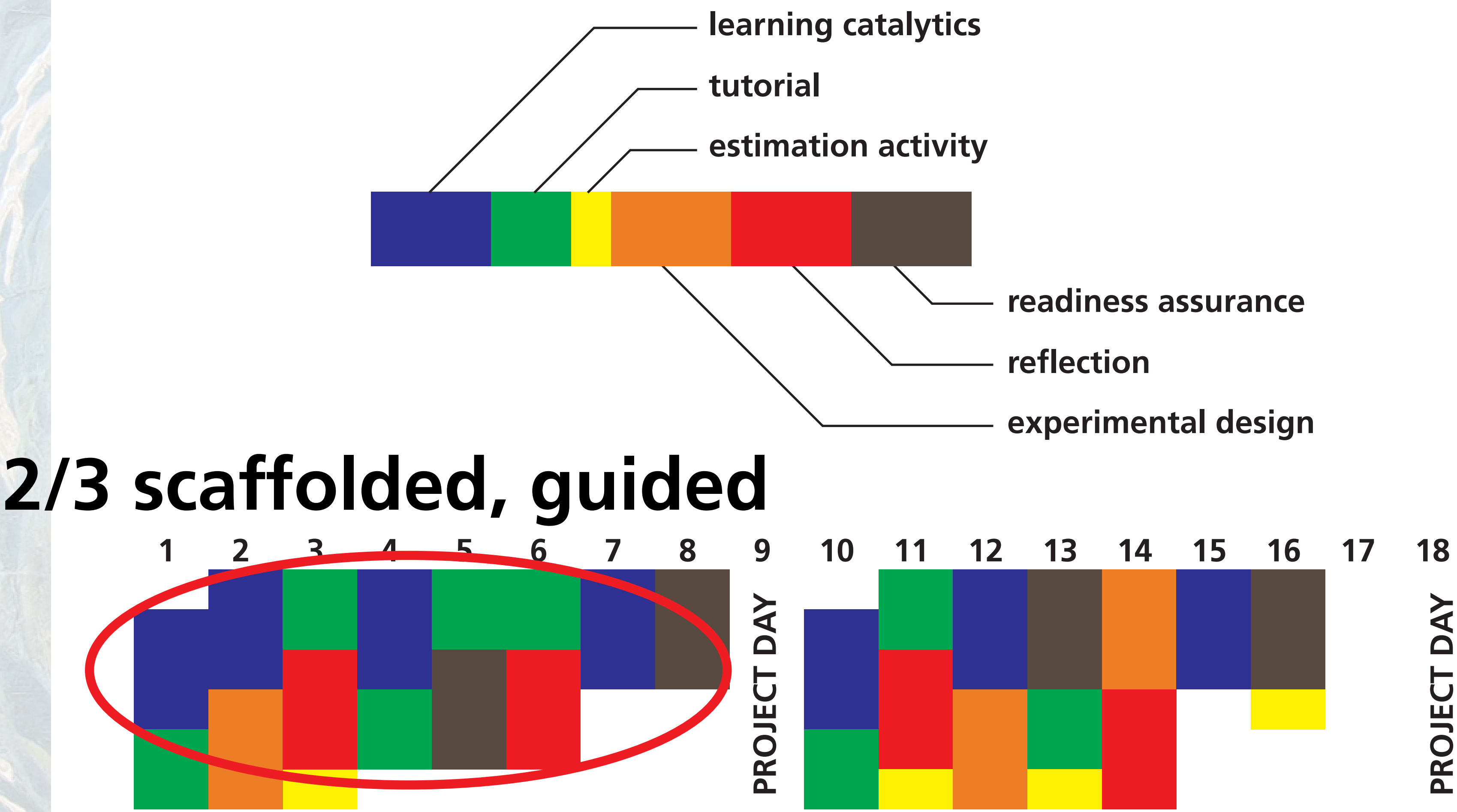
1 design   2 approach

In-class activities



1 design   2 approach

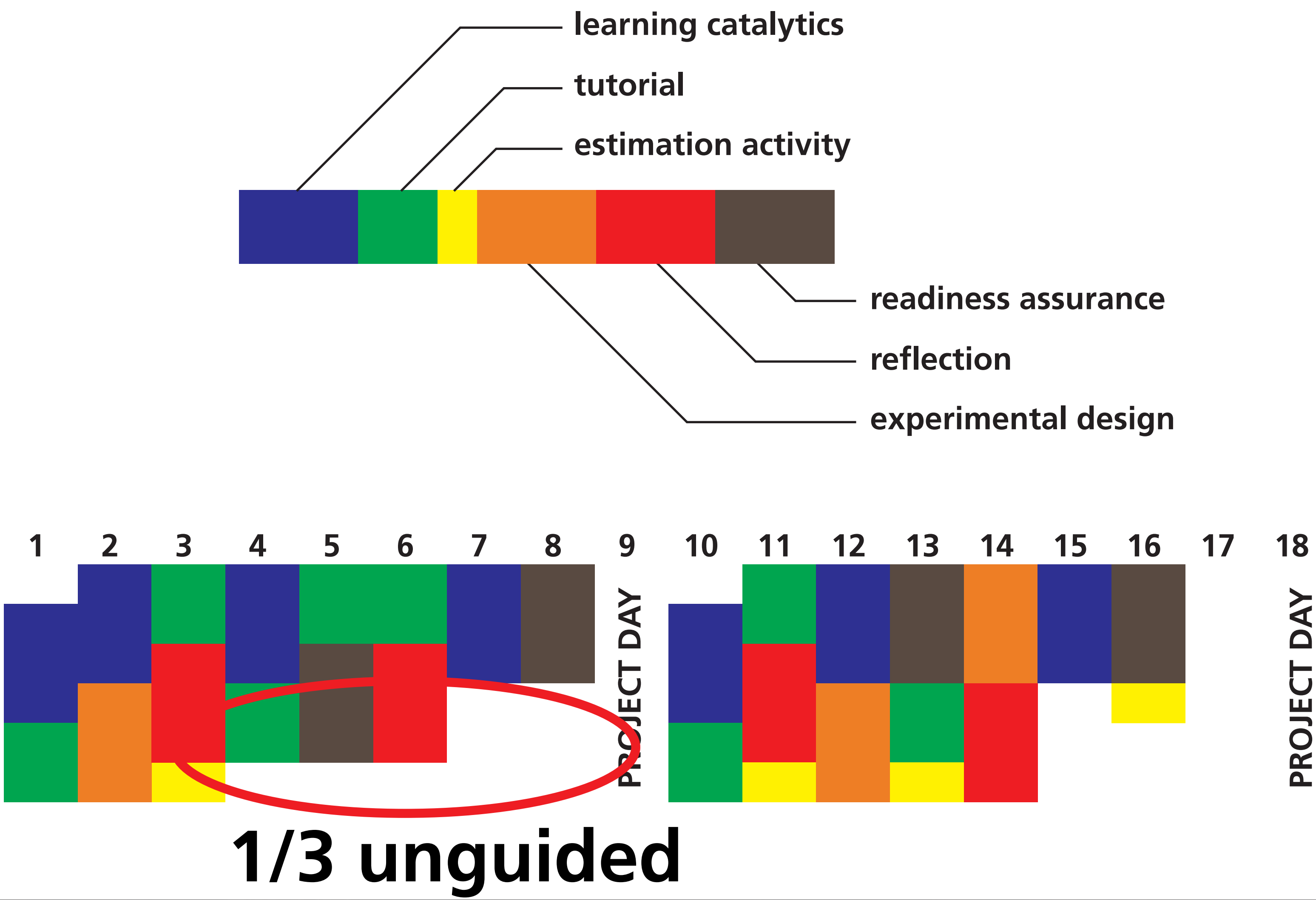
In-class activities



1 design

2 approach

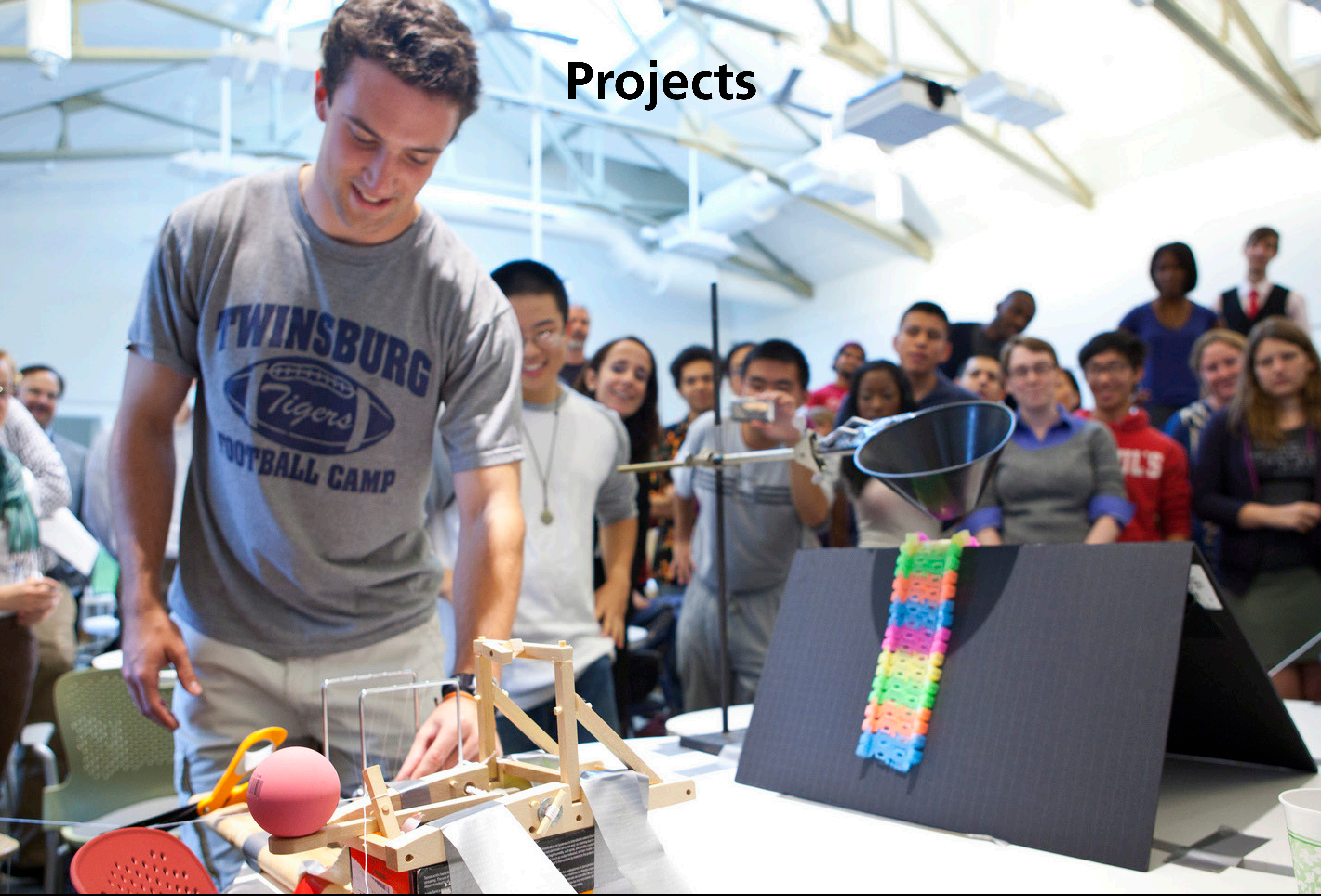
In-class activities



1 design

2 approach

Projects



1 **design**

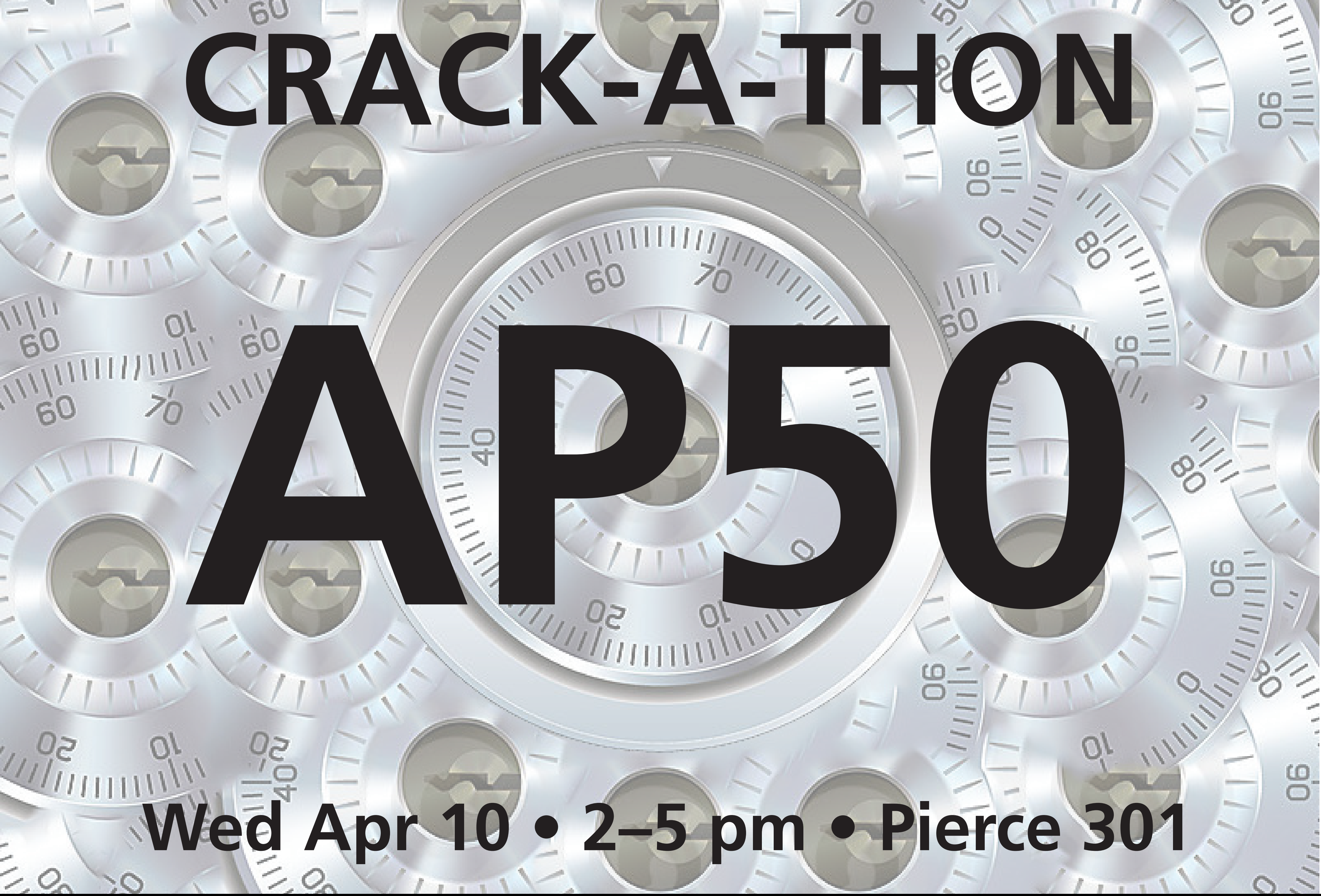
2 **approach**

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

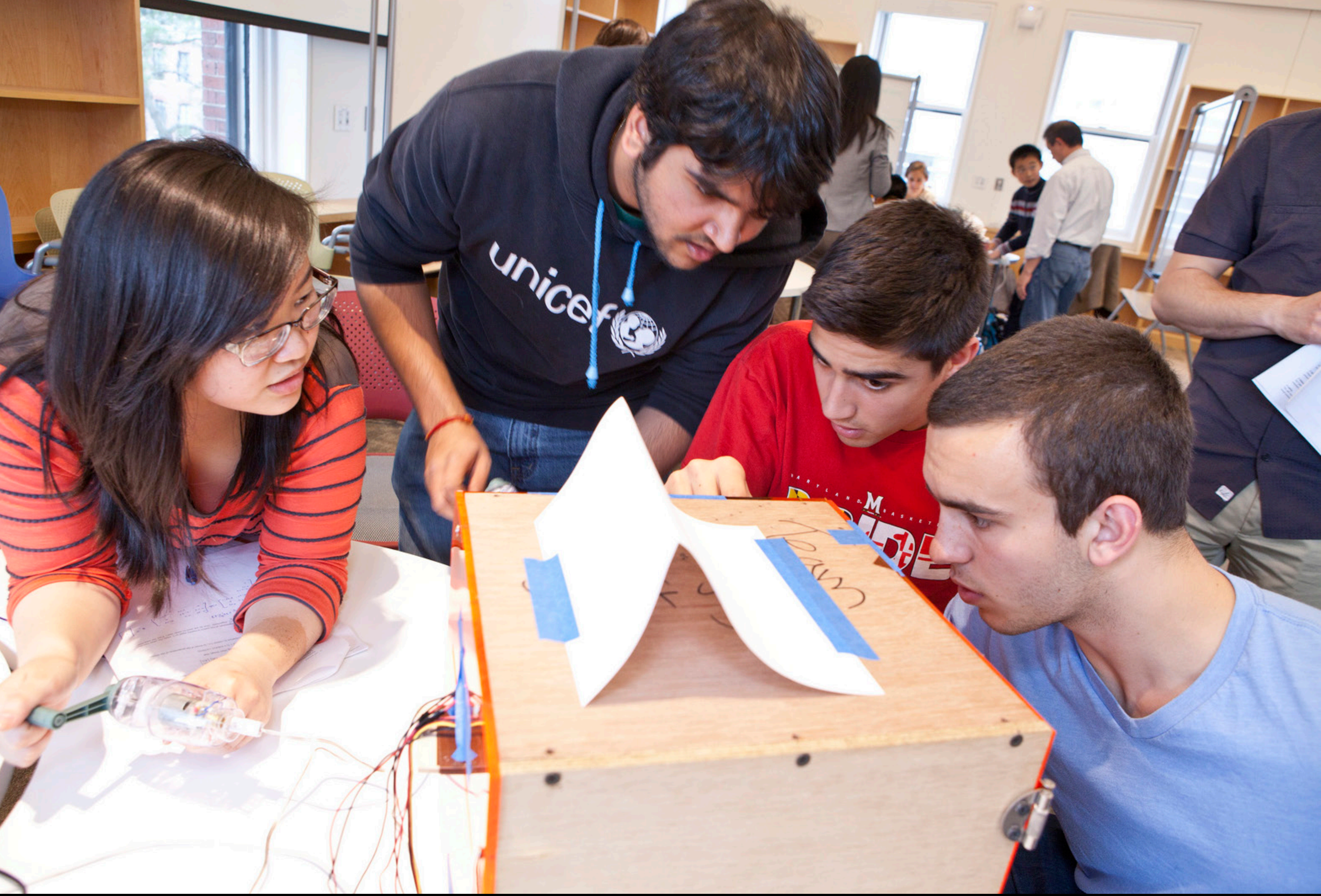
Fall	Spring
Rube Goldberg	Environment
Mission to Mars	Safe cracking
Musical Instrument	Energy



1 design 2 approach

1 design

2 approach



1 design

2 approach

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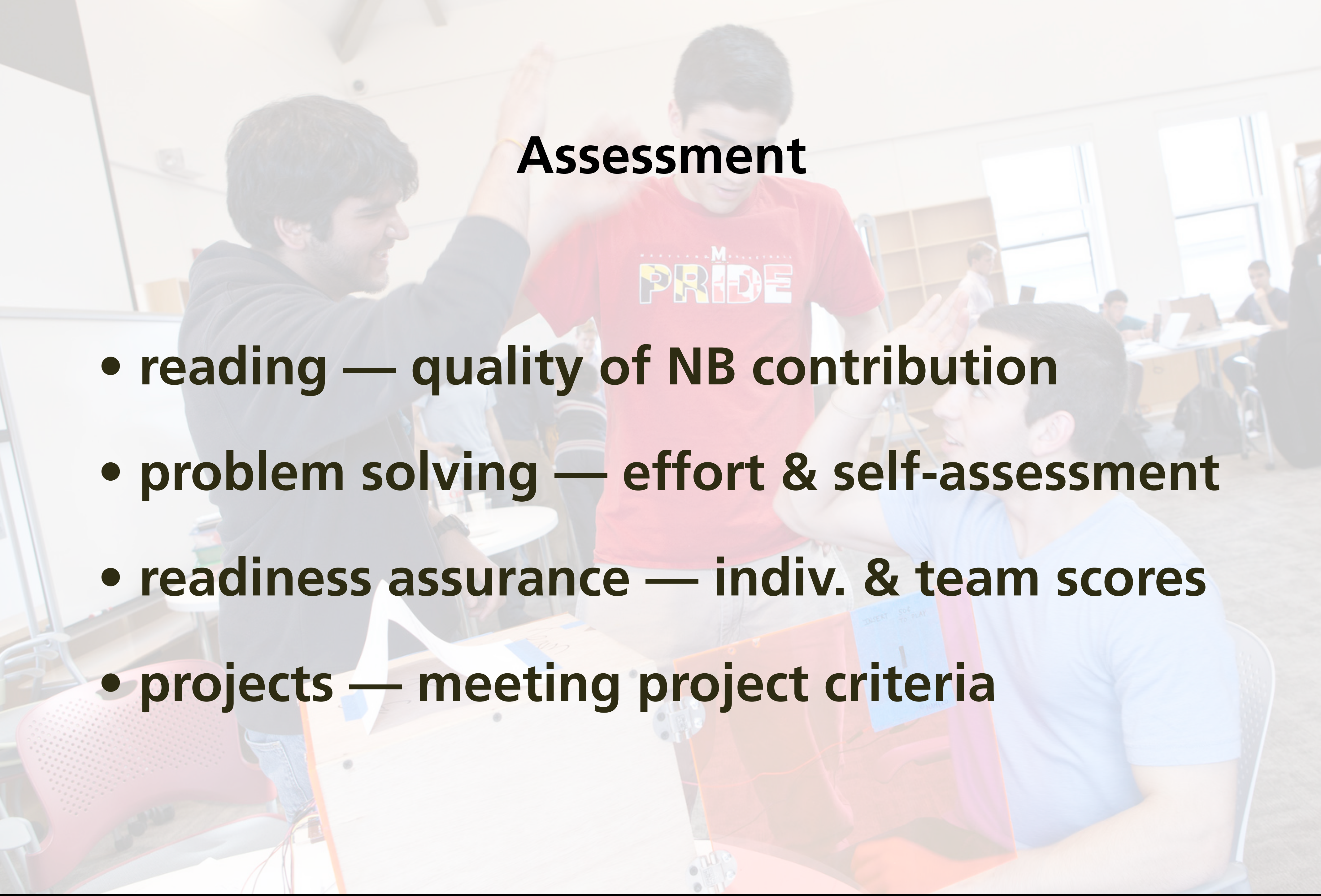


Assessment

- reading — quality of NB contribution
- problem solving — effort & self-assessment
- readiness assurance — indiv. & team scores
- projects — meeting project criteria

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*!

Self-directed learning

1 design

2 approach

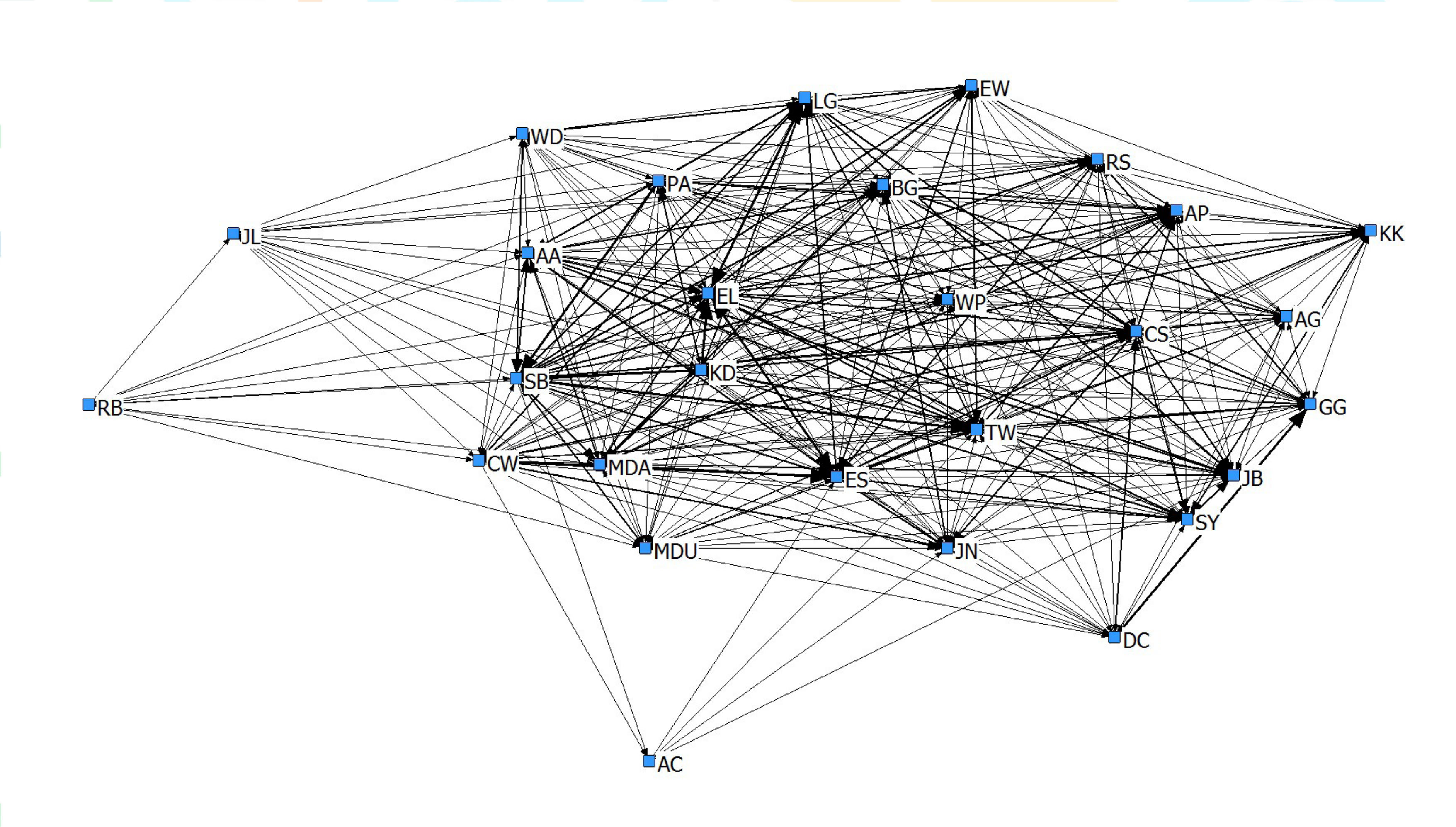
3 results

Self-directed learning

NB data shows:

- student spend on average 2.3 hrs/chapter
- 160–230 annotations/chapter (5–7/stu)

Self-directed learning



Self-directed learning

"I think I am having a little too much fun annotating in the text… ☺ It is a great way to communicate throughout the class!"

Content mastery

- FCI normalized gain 0.56
- Problem solving ability on par or better

1 design 2 approach 3 results

Can create ownership of learning physics!

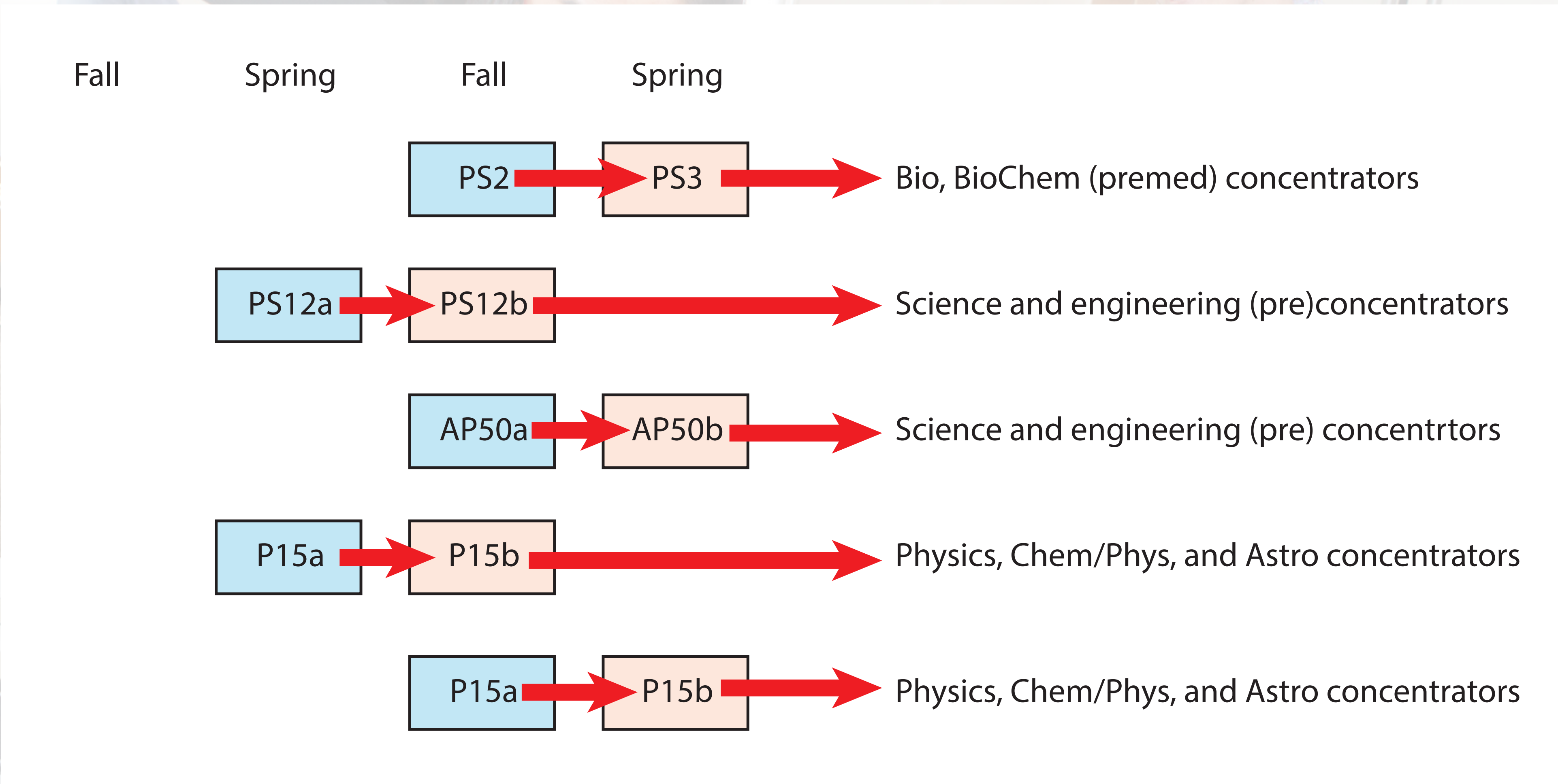
"you come out with so much know-
ledge and experience and fun"

where does AP50 fit?

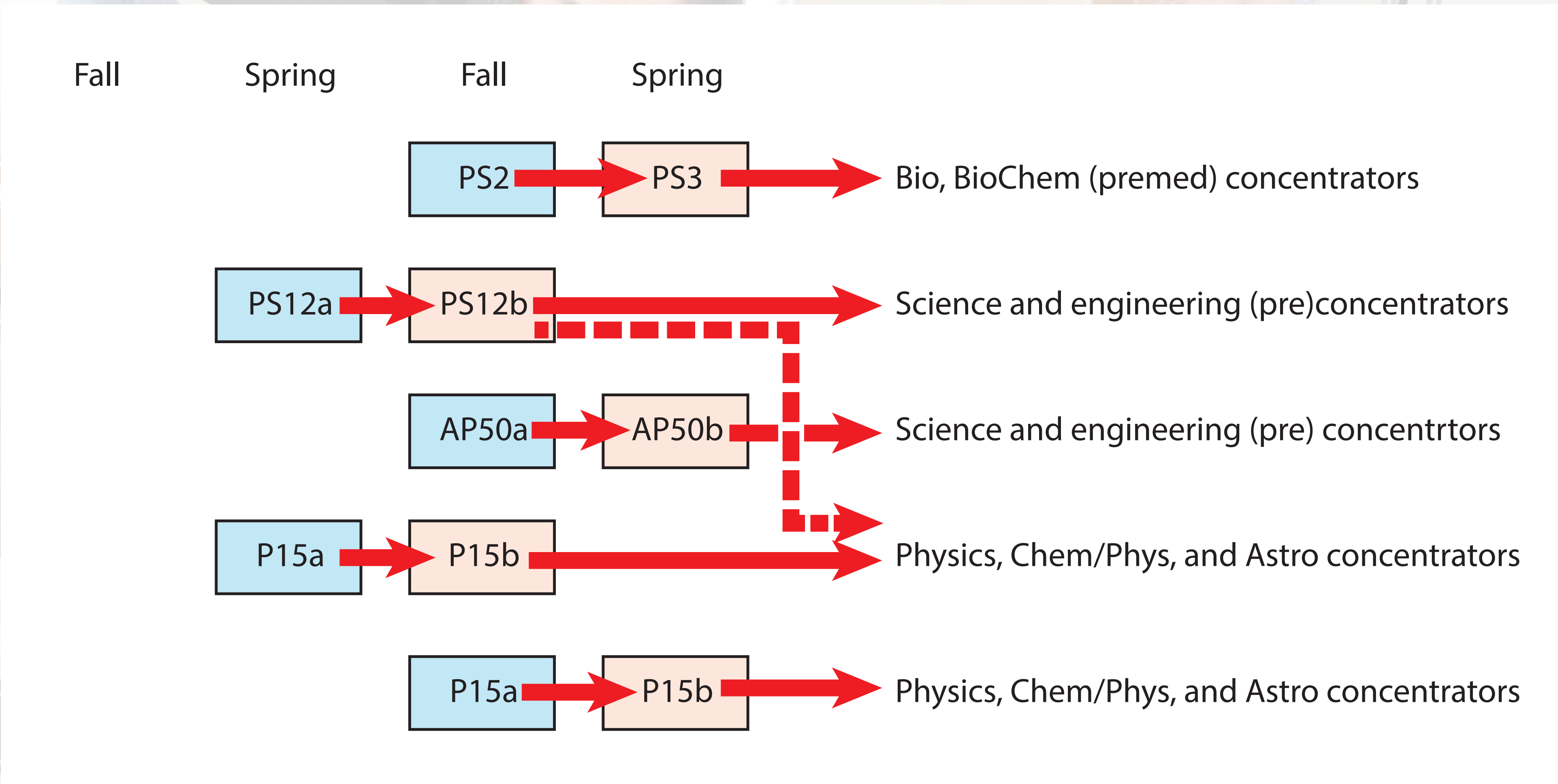
Intro physics course matrix

Fall	Spring	Fall	Spring	
PS2	PS3	PS2	PS3	Bio, BioChem (premed) concentrators
PS12b	PS12a	PS12b	PS12a	Science and engineering (pre)concentrators
AP50a	AP50b	AP50a	AP50b	Science and engineering (pre) concentrtors
P15b	P15a	P15b	P15a	Physics, Chem/Phys, and Astro concentrators
P15a	P15b	P15a	P15b	Physics, Chem/Phys, and Astro concentrators

Intro physics course matrix

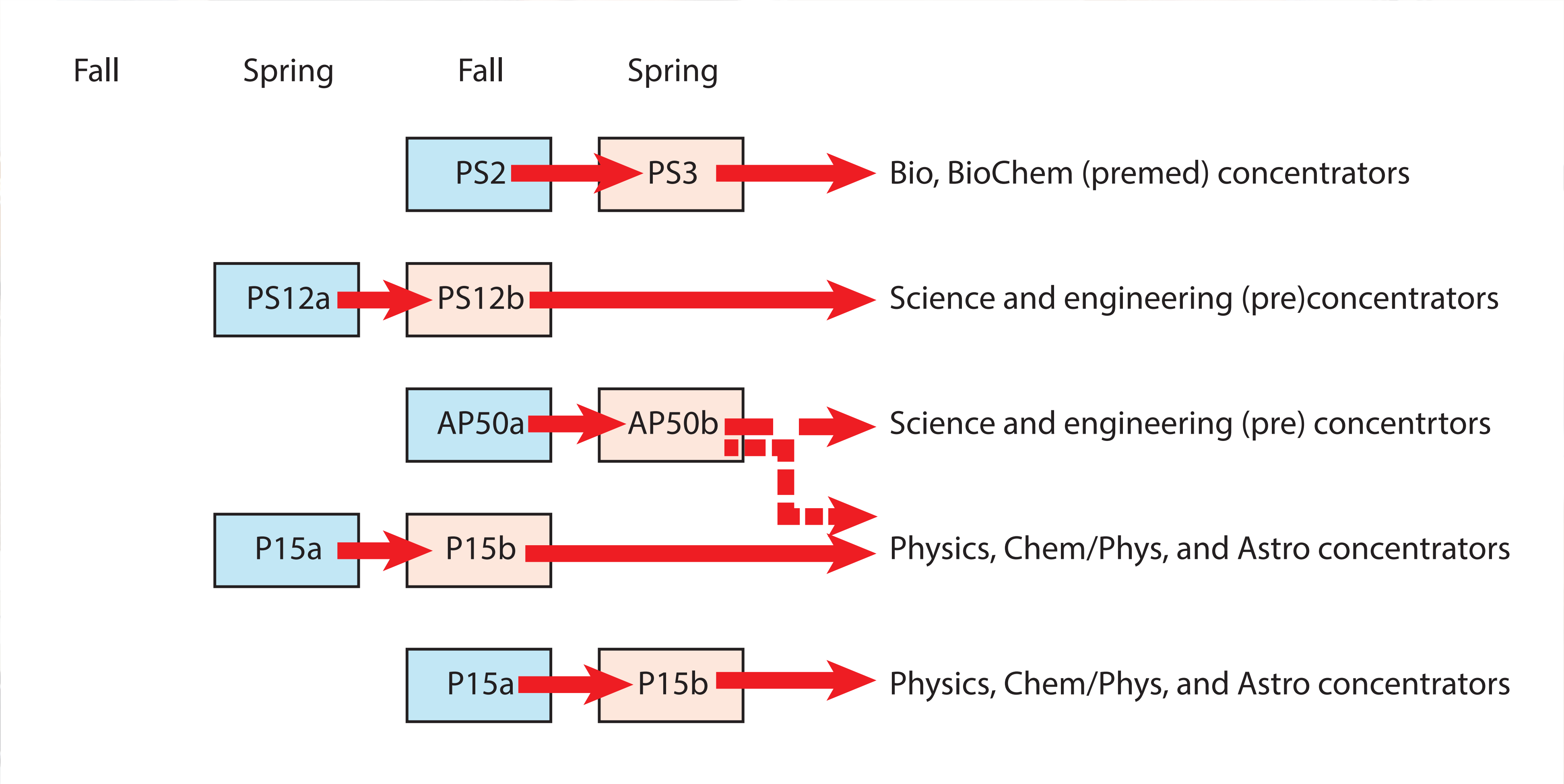


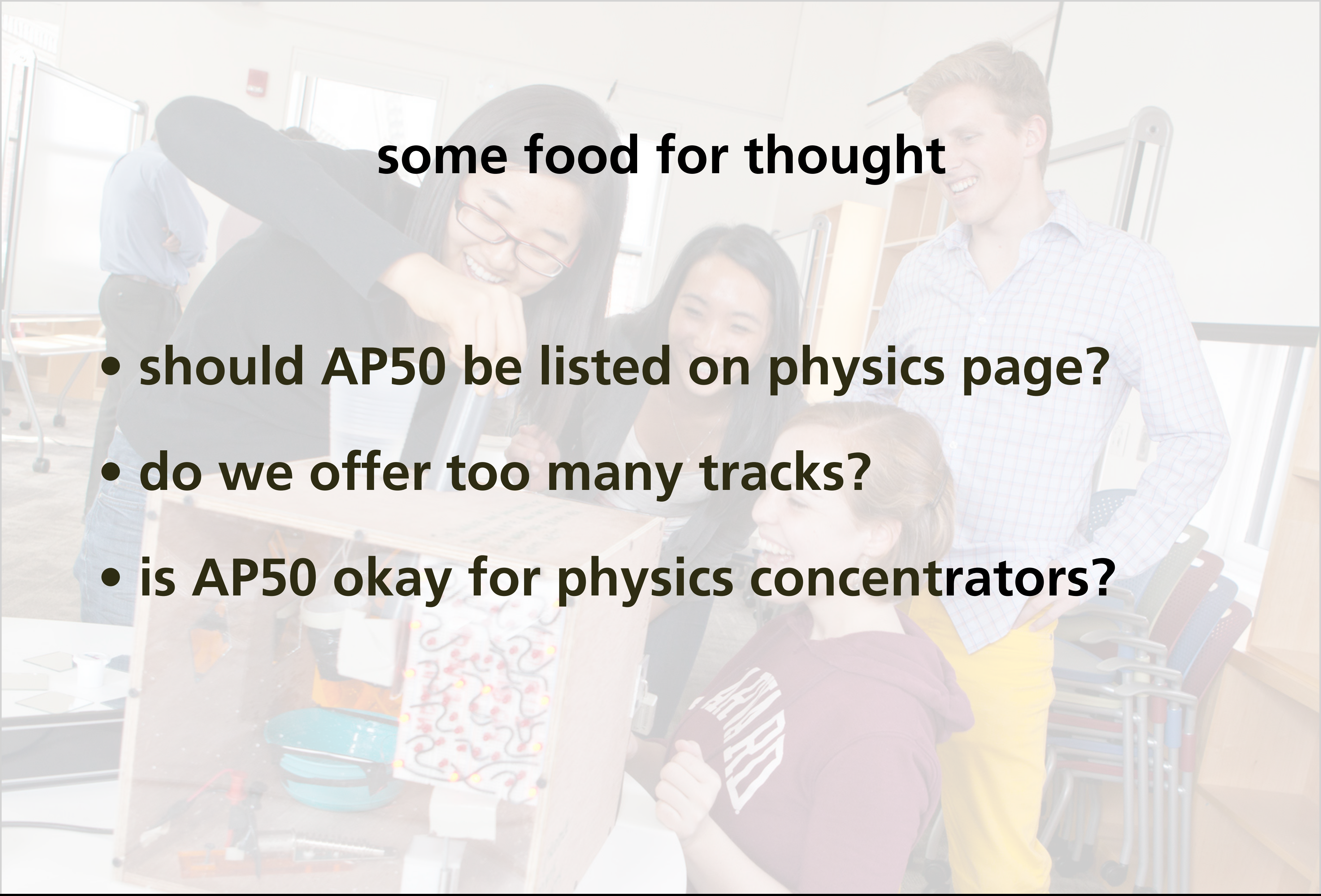
Intro physics course matrix



1 design 2 approach 3 results

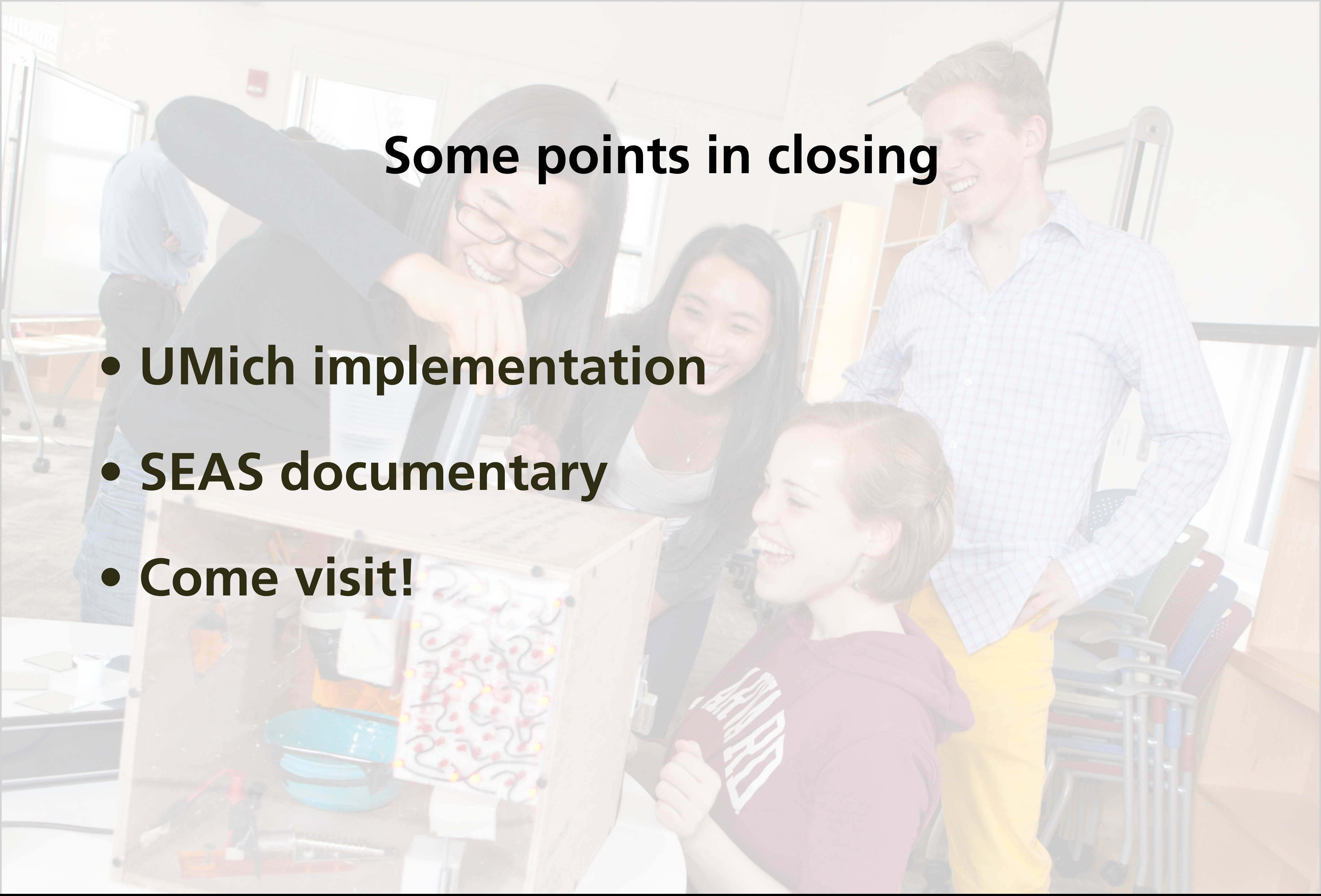
Intro physics course matrix





some food for thought

- should AP50 be listed on physics page?
- do we offer too many tracks?
- is AP50 okay for physics concentrators?



Some points in closing

- UMich implementation
- SEAS documentary
- Come visit!

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mazur.harvard.edu

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