Using seminar-based instruction to convey contemporary research to undergraduates

APS March Meeting
Dallas, TX, 21 March 2011

Introduction

Write down some of the skills that made you become successful in your career — something you are good at, something that you *know* you do well.

Introduction

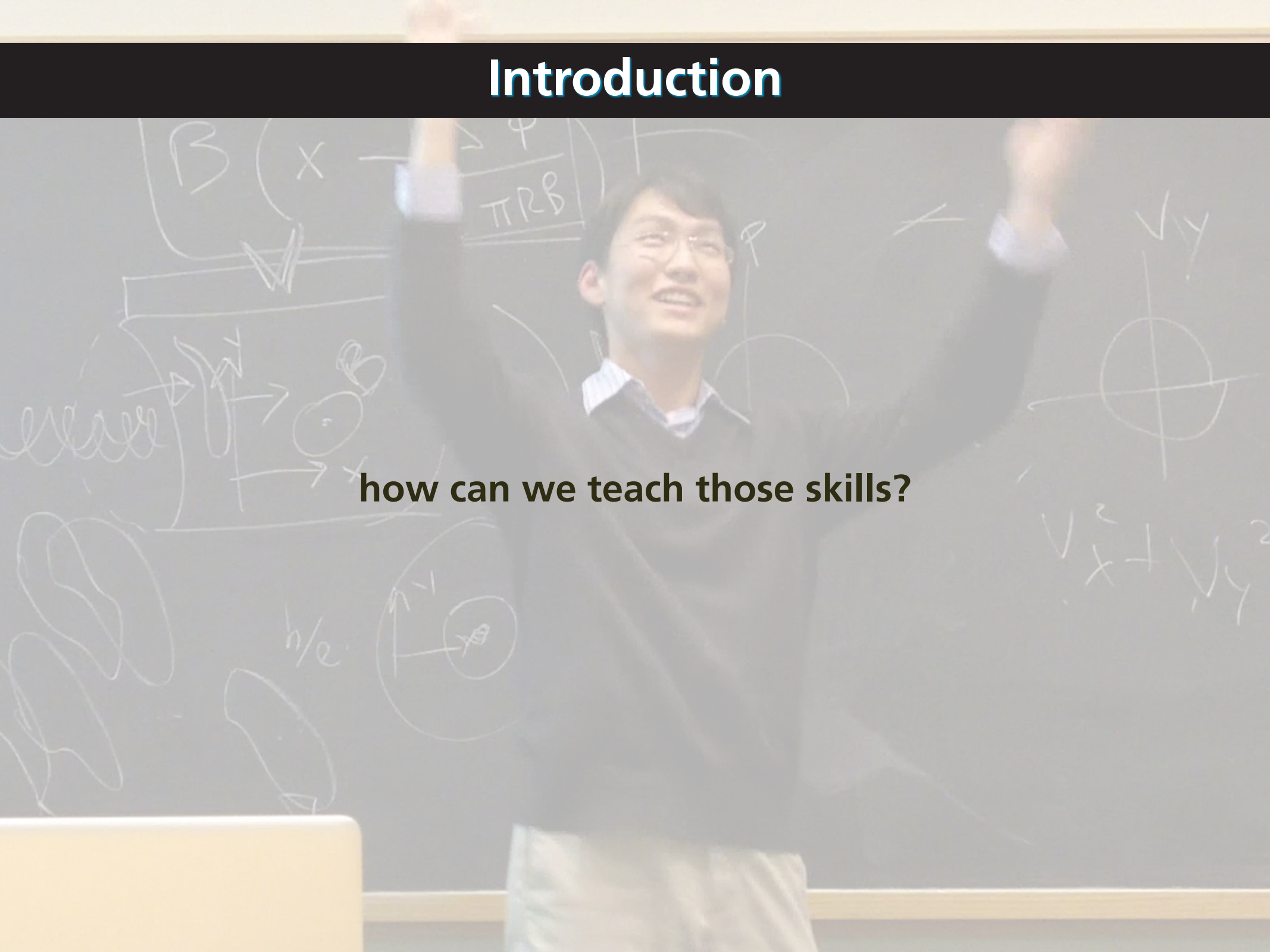
Write down some of the skills that made you become successful in your career — something you are good at, something that you *know* you do well.

***How* did you become good at this?**

My message

many important skills not formally taught

Introduction



how can we teach those skills?

Introduction

focus on skills, not concepts

Introduction

origin of course:

weekly research seminars by faculty for incoming GS

Introduction

Physics 95: “Topics in current research”

8–14 majors, mostly juniors and seniors

condensed matter physics, atomic physics, biophysics, high energy physics, cosmology, astrophysics, string theory…

Introduction

Original course structure

- Wednesday night: seminar led by faculty member
- Monday: preparatory lecture by instructor
- Final term paper

Introduction

Outcome

Introduction

Outcome

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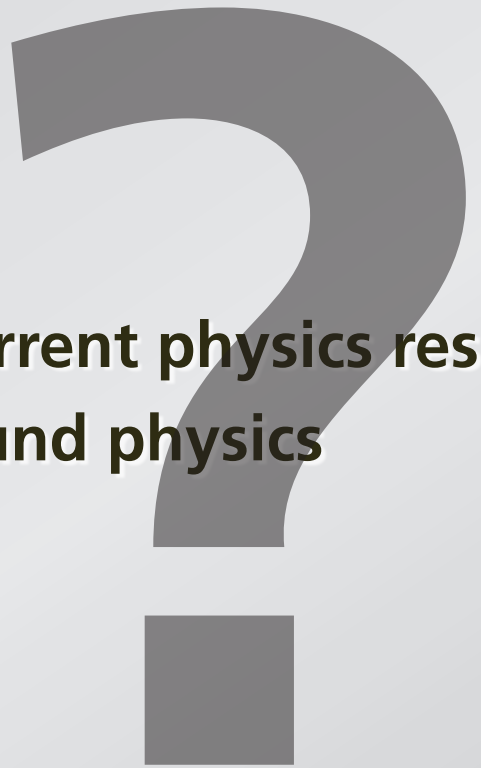
Outcome

- ideas about current physics research
- some background physics

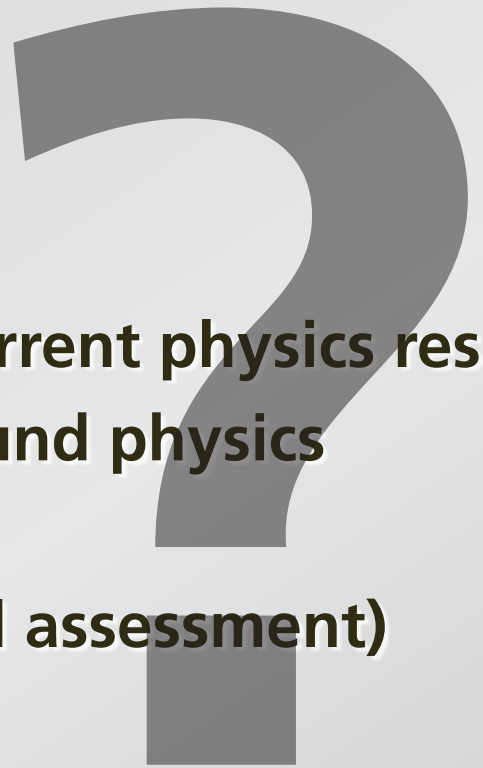


Introduction

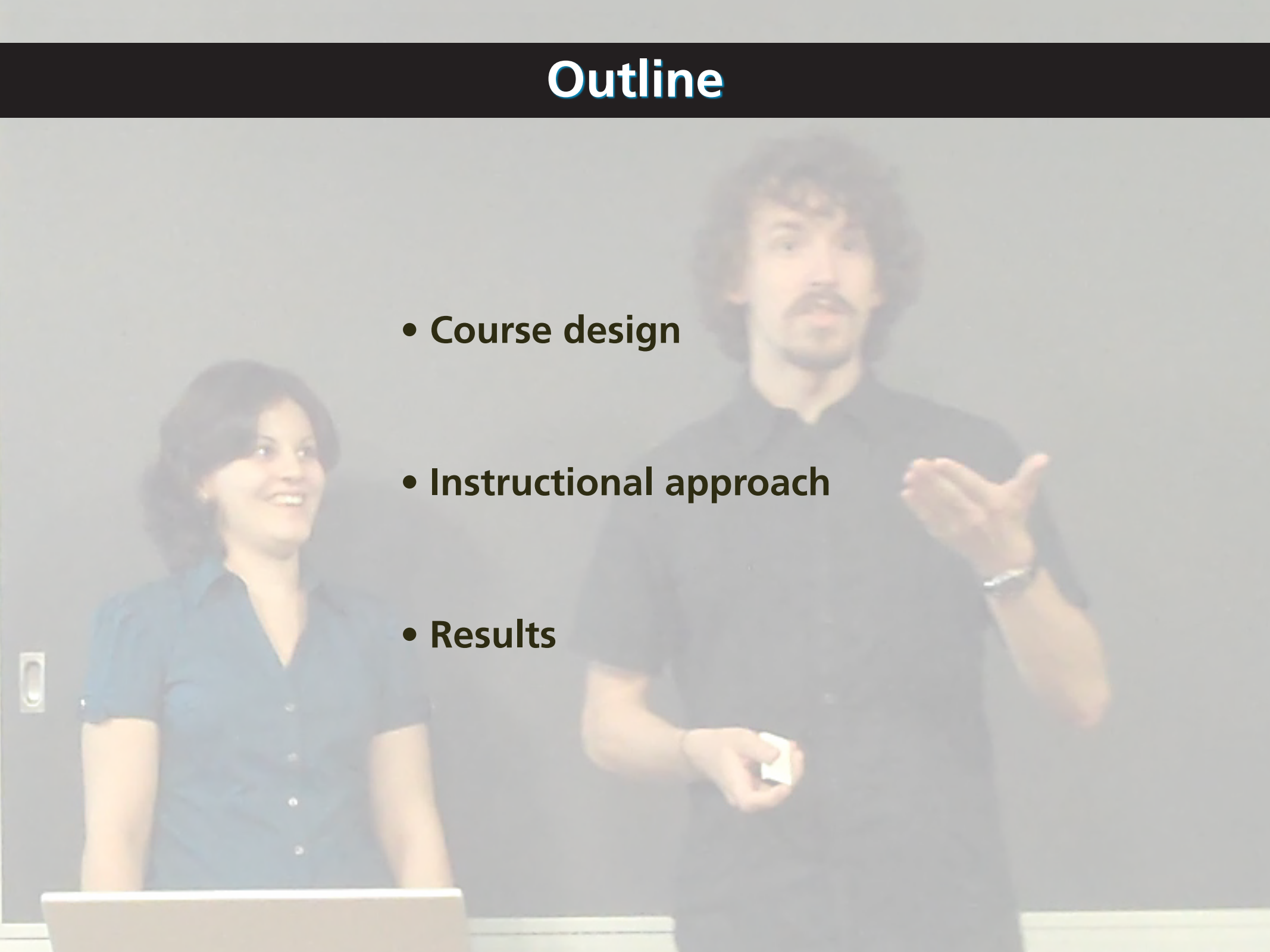
Outcome

- ideas about current physics research
- some background physics

(but very limited assessment)



Outline



- Course design
- Instructional approach
- Results

Course design

how can I teach 22 different subjects effectively?

Course design

have students teach!

Course design

how to keep non-presenters engaged?

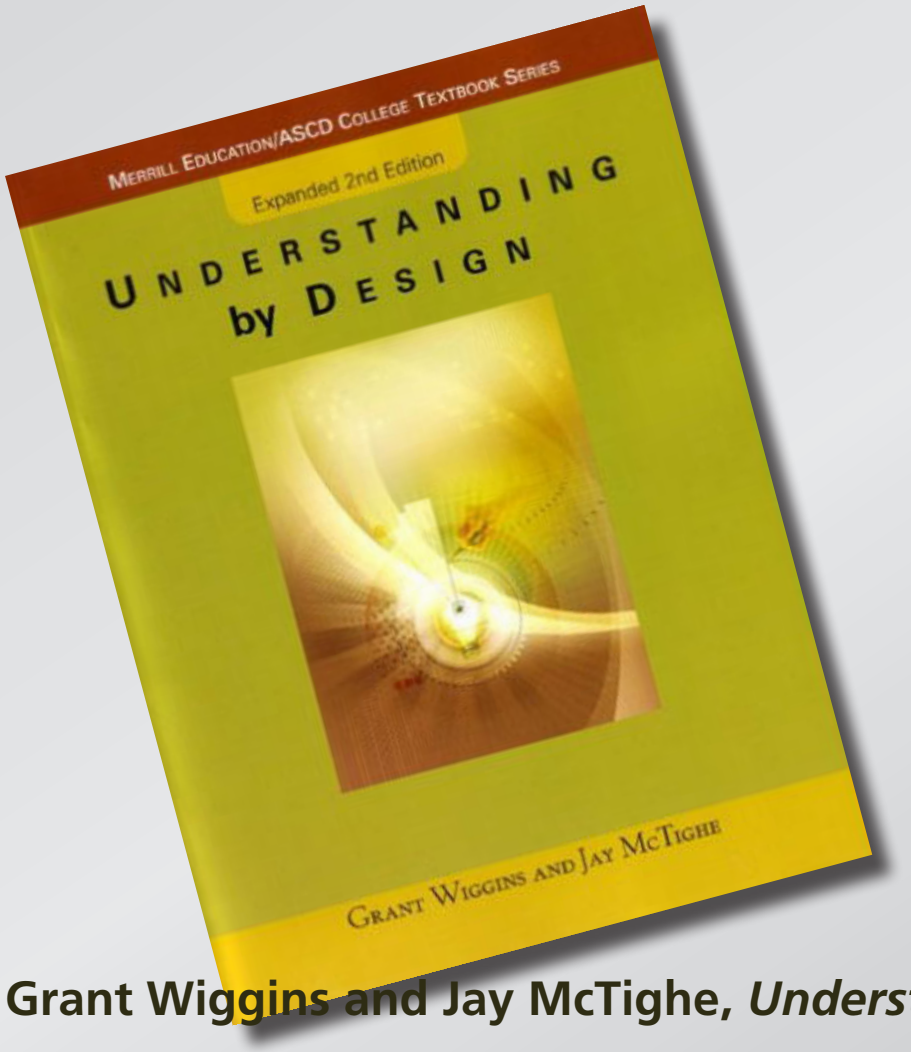
Course design

how to keep non-presenters engaged?

evaluate on discussion skills

Course design

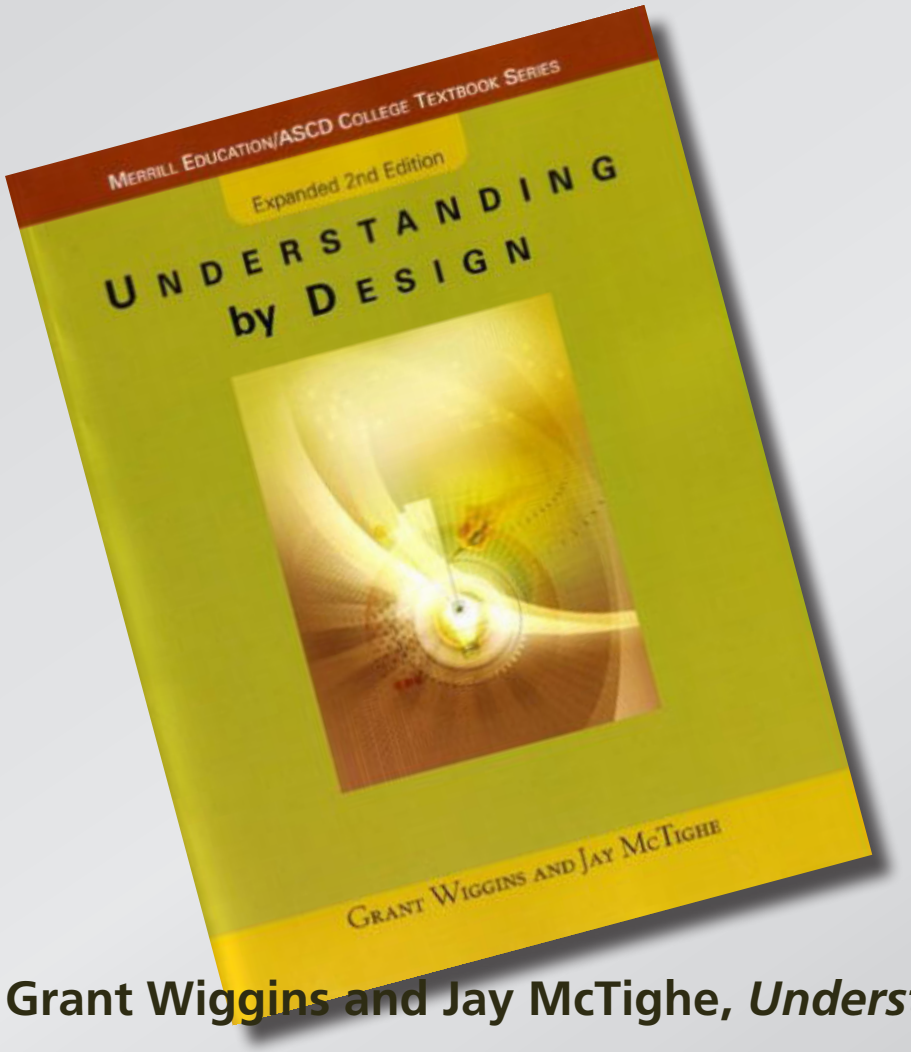
Setting learning goals



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

Course design

Setting learning goals

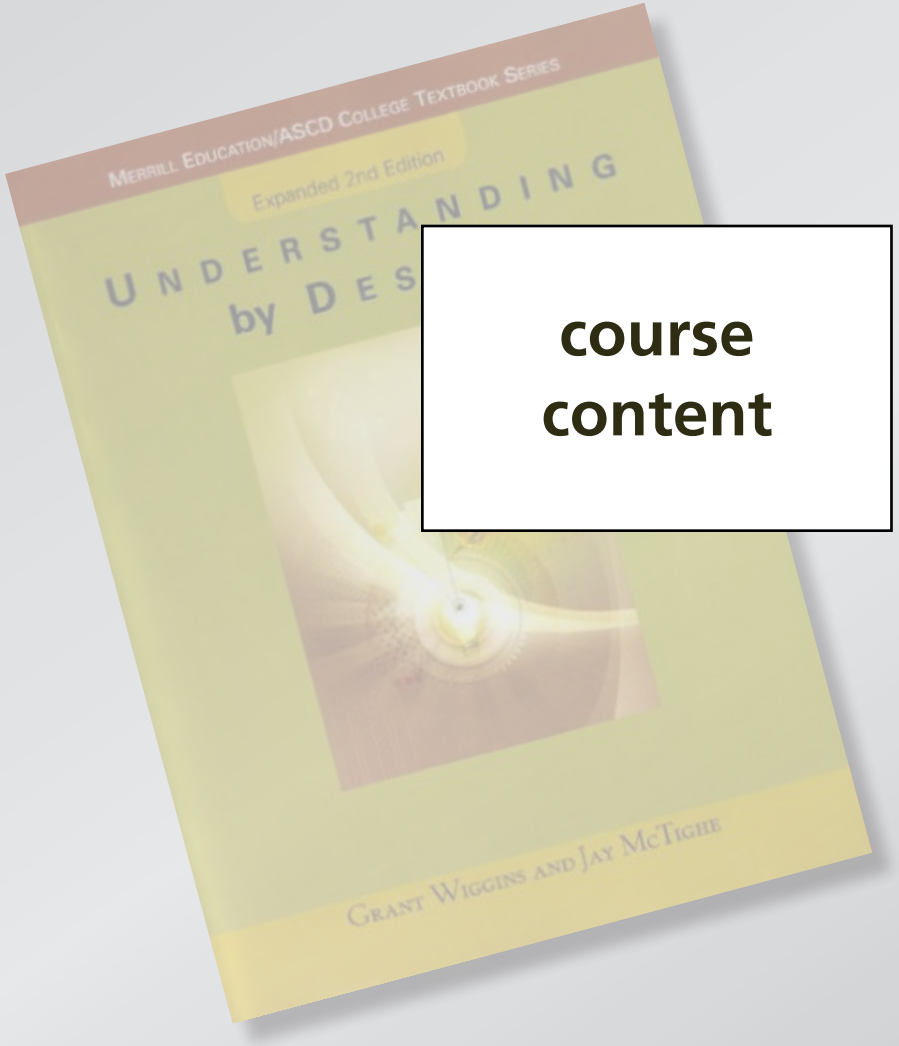


- approach, not content
- focus on understanding
- backward design

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

Course design

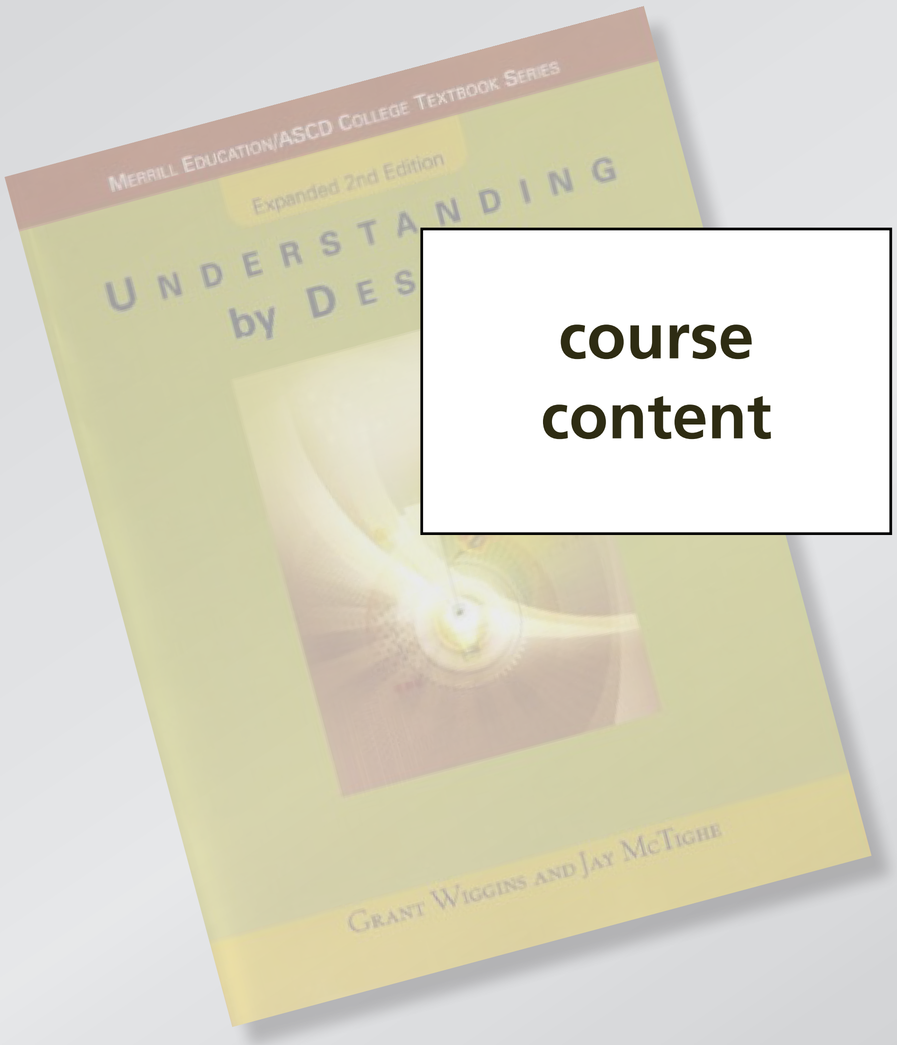
Traditional approach to course planning



course content

Course design

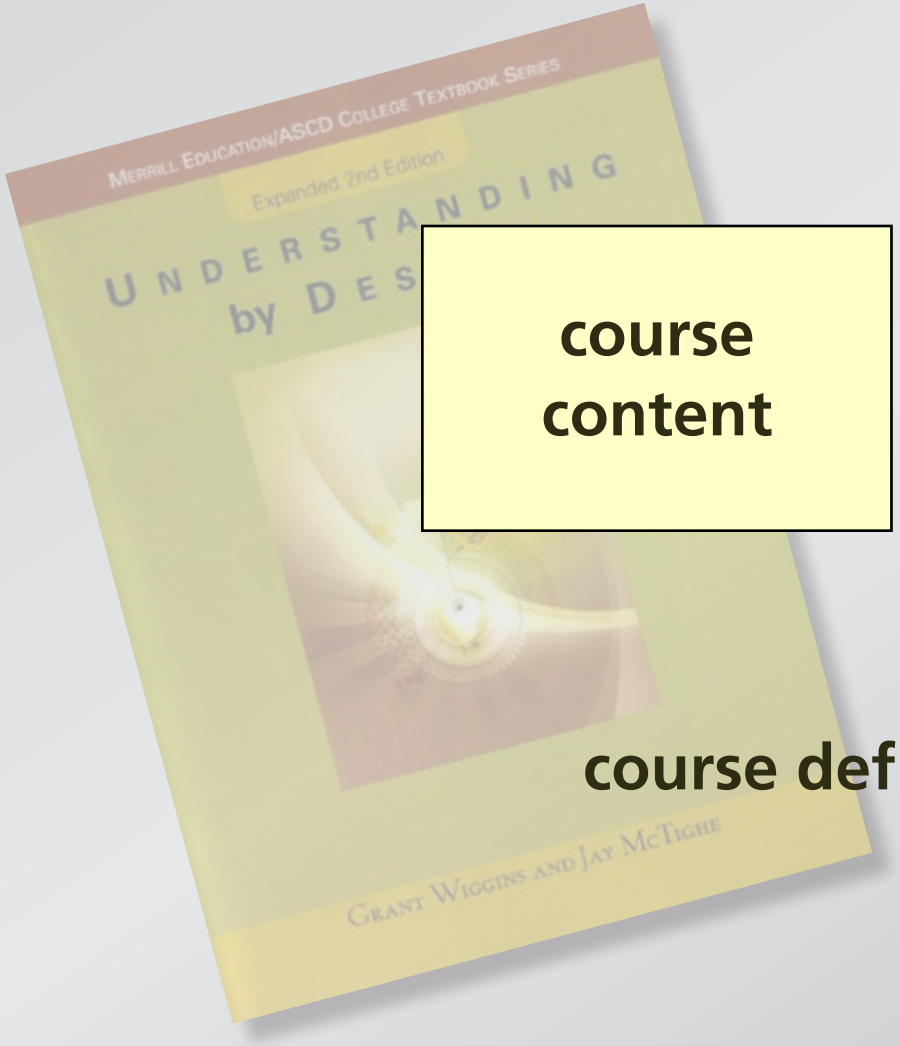
Traditional approach to course planning



course content → assessment

Course design

Traditional approach to course planning



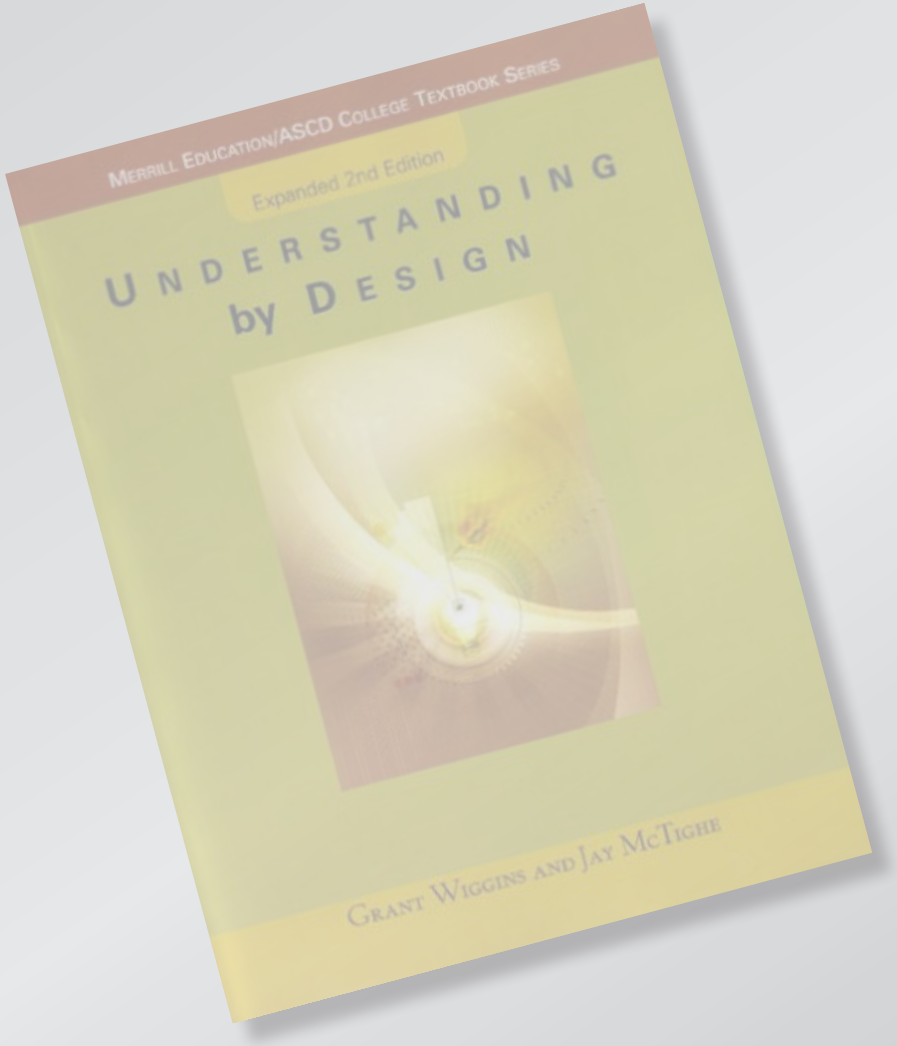
course content

assessment

course defined by content

Course design

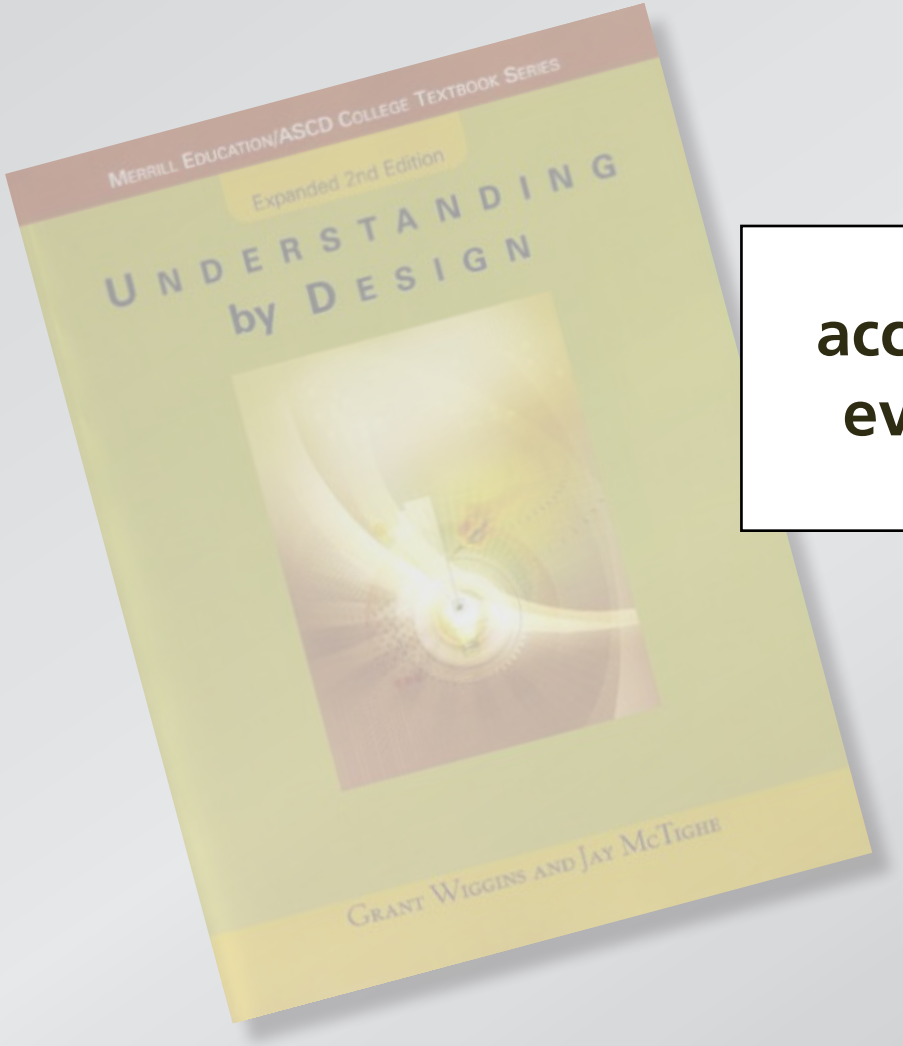
Backward design



desired outcomes

Course design

Backward design

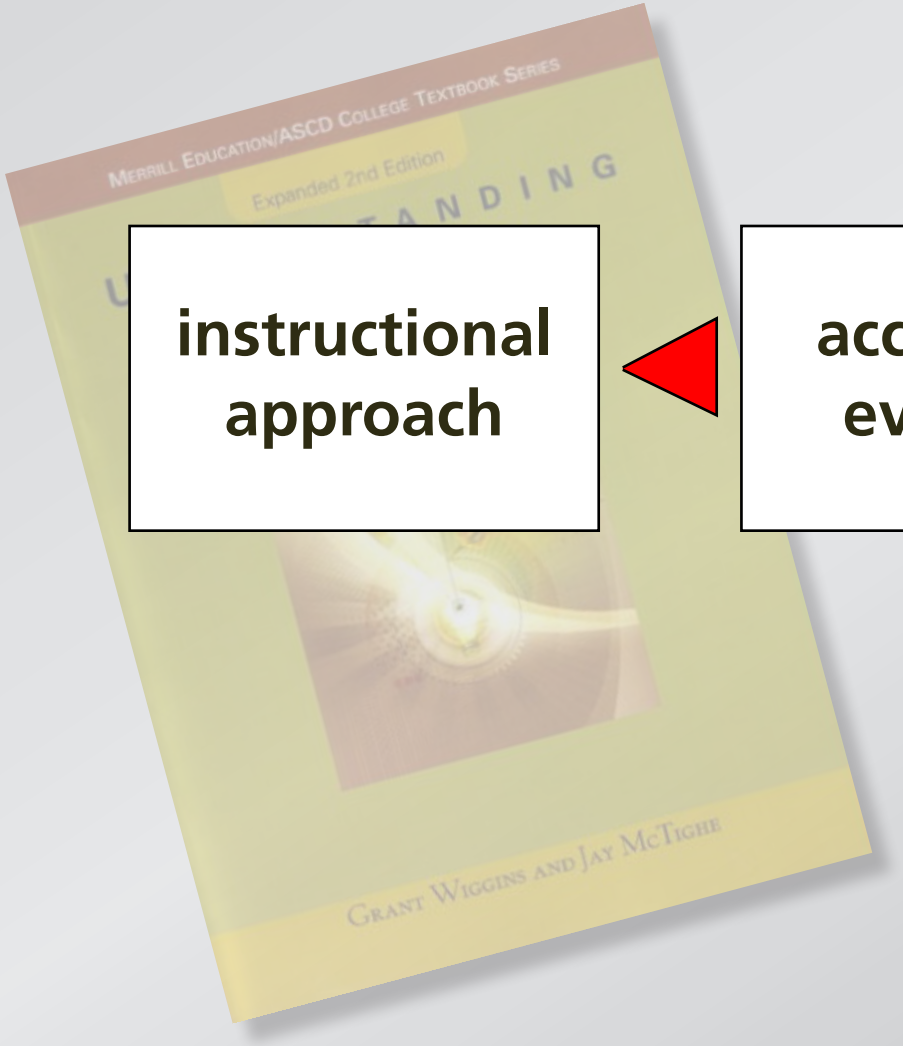


acceptable evidence

desired outcomes

Course design

Backward design



instructional approach

acceptable evidence

desired outcomes

Course design

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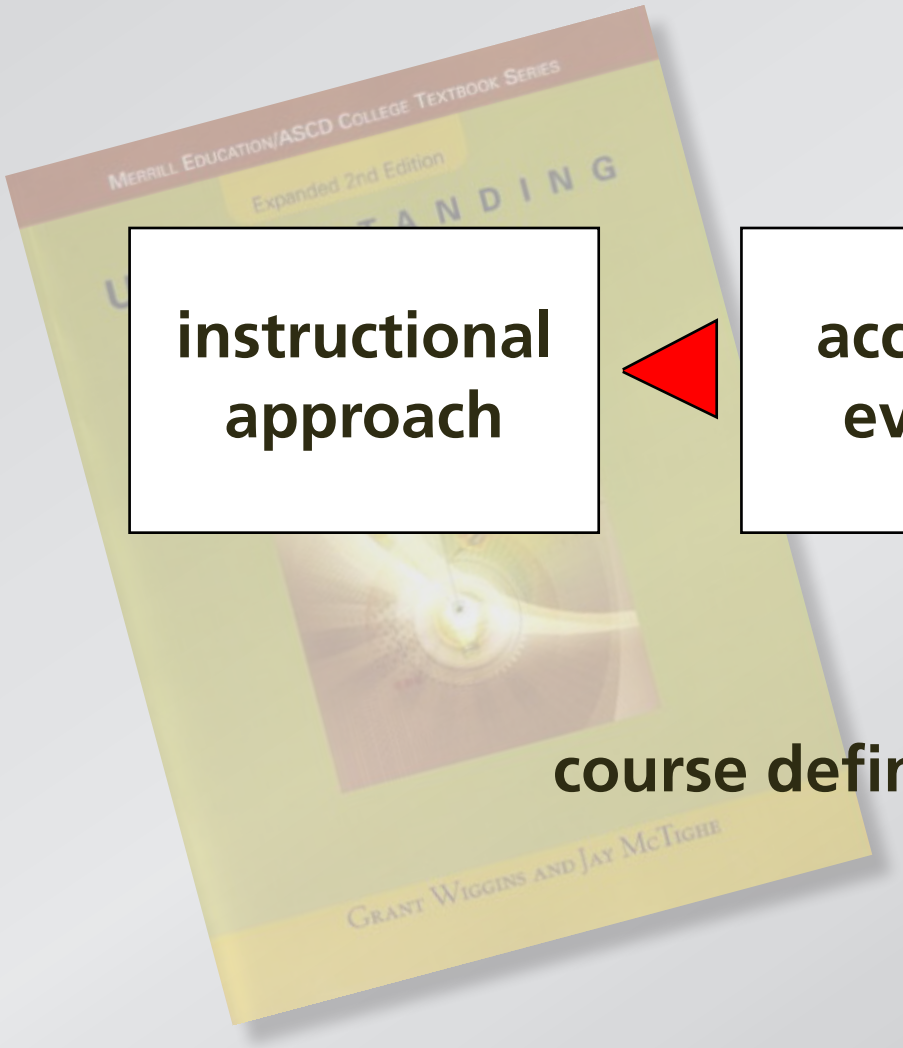


instructional approach ◀ **acceptable evidence** ◀ **desired outcomes**

course defined by outcomes

Course design

Physics 95 — Fall 2009
Modern Research Tutorial

Welcome to Physics 95, a course for juniors and seniors interested in learning about leading edge research, focusing on research carried out in the Harvard Physics department. My goals for this course are to give you a taste of graduate-level research in physics and at the same time help you develop skills that will be useful in your career regardless of your field: reading, listening, presentation, writing, discussion, and evaluation skills. This course is for you if are interested in:

- learning about cutting edge research
- interacting with leading professors in the field
- sharpening your leadership skills

As the instructor for this course, I look forward to getting to know you this semester. I take my teaching duties very seriously and will work hard to attain these goals and make Physics 95 a rewarding and useful experience for you. I will make myself as accessible as possible — I do want to interact with you in class and out of class. I encourage you to stop by my office or call me; my office, home, and cell phone numbers are below.

I look forward to working together this semester!

Eric Mazur

Contact information

Eric Mazur
mazur@physics.harvard.edu

Pierce Hall 233
Home (until 11 pm)
Cell (any time)
AIM

5-8729
(978) 371-9063
(978) 394-1042
eric_mazur@mac.com

Course Web site: http://mazur-www.deas.harvard.edu:8182/students/?courseID=407

Throughout the term, this site is your primary resource for accessing reading materials and submitting assignments.

started:

ssignment on the course Web site (as soon as possible)
re willing to give one of the first four presentations
Wednesday Night Research Seminar

Course design

After course, will be able to

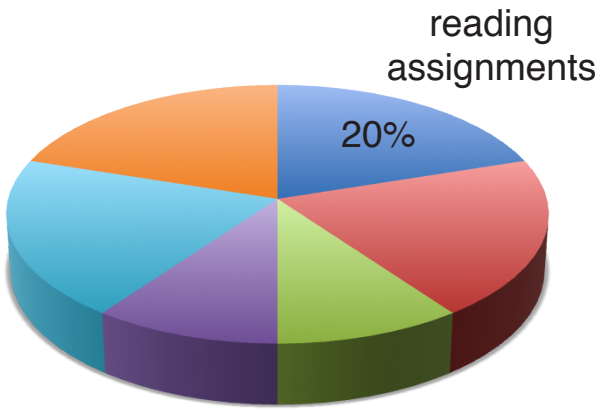
- draw on broad knowledge base in current physics
- research new (and unfamiliar) topics
- participate in discussions with peers and experts
- design and deliver effective presentations
- write scientific article for non-science audience
- evaluate your own and others’ work

Course design

evaluation

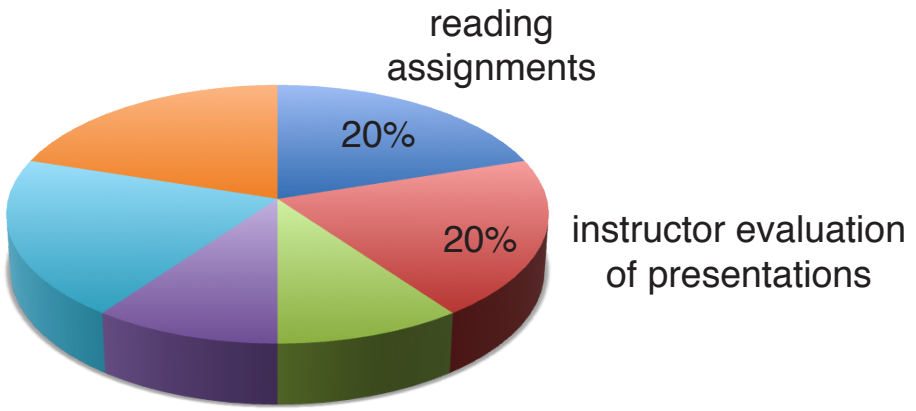
Course design

evaluation



Course design

evaluation



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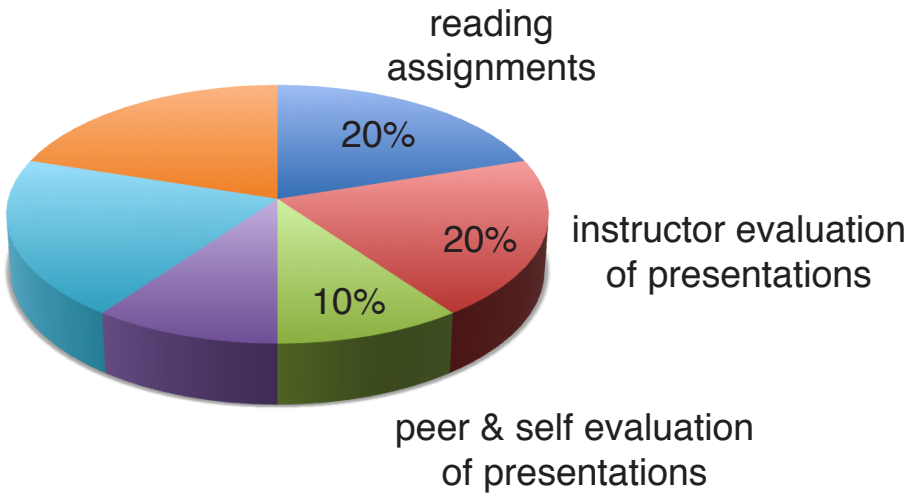

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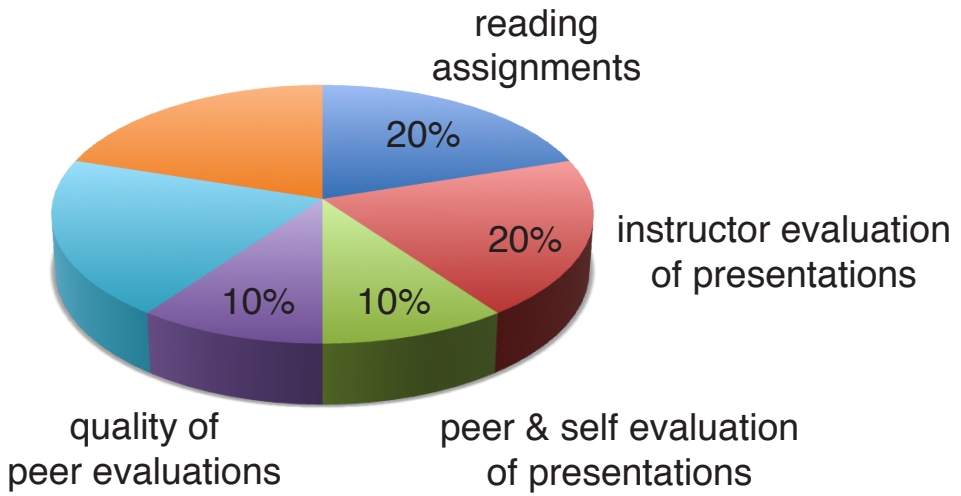

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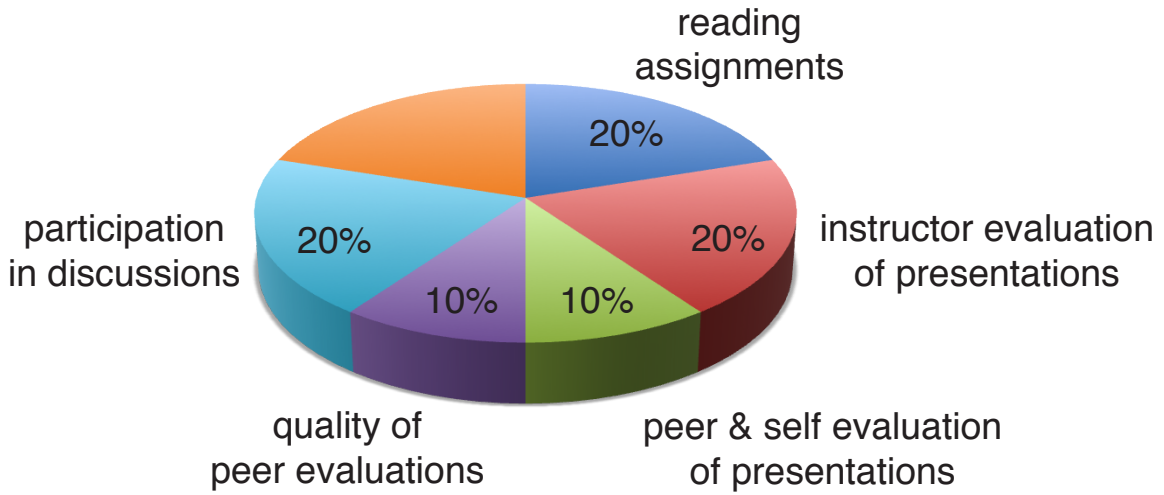

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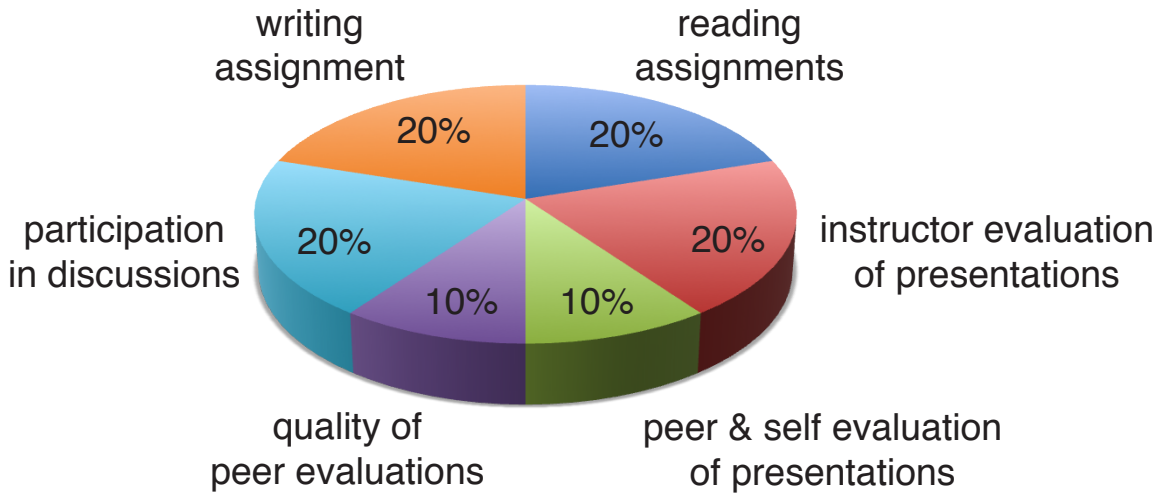


Course design

Rubric-based evaluation

PRESENTATION RUBRIC

Presenter: _____

		1 = needs improvement (does not meet expectations entirely)	**2 = satisfactory** (meets expectations **(what you should aim for)**)	**3 = admirable** (exceeds expectations **(no more than seven** in this category!**)**)	**Score (1–3)**
Nonverbal skills	Posture/poise	Slouches or slumps a bit or looks somewhat nervous/insecure	Stands up straight, displays little or no tension	Stands up straight, looks relaxed, confident, and in control	
	Eye contact	Often looks away, at screen, at notes, or always looks at the same person or group of persons	Consistent use of direct eye contact with audi som	Holds attention of entire audience with	
	Gesticulation/body language and facial expression	Not used much or used ineffectively	Use subj		
Vocal skills	Enthusiasm	Sometimes reflects lack of interest or negativity toward subject OR not genuine	Ofte the		
	Volume	Sometimes too soft to be heard by all audience members	Mos audi		
	Pitch/inflection	Pitch was not used to maintain interest or convey emotion OR was used inappropriately	Sati con		
	Vocabulary	Unexplained terms/jargon used	Voc		
	Clarity of speech	Occasionally mumbles or can not be understood or mispronounces words	Arti the		
	Pauses not intentionally used or		Pau effe dra		
			Less		

Rubric used for Calibrated Peer Review

WRITING RUBRIC

		1 = needs improvement (does not meet expectations entirely)	**2 = satisfactory** (meets expectations **(what you should aim for)**)	**3 = admirable** (exceeds expectations (**rarely** selected)
Structure	Title	Wordy, long, unimaginative, or inappropriate title	Title appropriate for audience	Catchy title drawing a article
	Opening	Missing a "hook" or a lead in the first paragraphs AND does not orient reader to	Hook or lead present OR first few paragraphs orient reader to subject	Hook or lead prese paragraphs orient
	Paragraph length	Many paragraphs are long (6 or more sentences)	Some paragraphs are long (6 or more sentences), most are short (1-5 sentences)	All paragraphs a sentences)
	Organization	Lacks organization; doesn't follow story; paragraph transitions missing	Sticks to story, paragraphs linked	Organization a compelling
	Closing	Does not end compellingly or with an	Does not end compellingly or with an	Ends comp
	Scientific facts	Contains incorrect, misstated, irrelevant, or unnecessary facts	All facts are 100% correct, relevant, and necessary	Includ testin
Ideas		Does not back up facts with proper or sources or evidence	All facts backed up with proper or convincing sources or evidence	Orig the
		available	Some originality apparent	

Course design

Standards for effective oral presentation

- Vocal skills
- Verbal skills
- Content
- Visuals
- Discussion management

Course design

Standards for effective writing

- Structure
- Content and ideas
- Mechanics

Course design

Standards for discussion participation

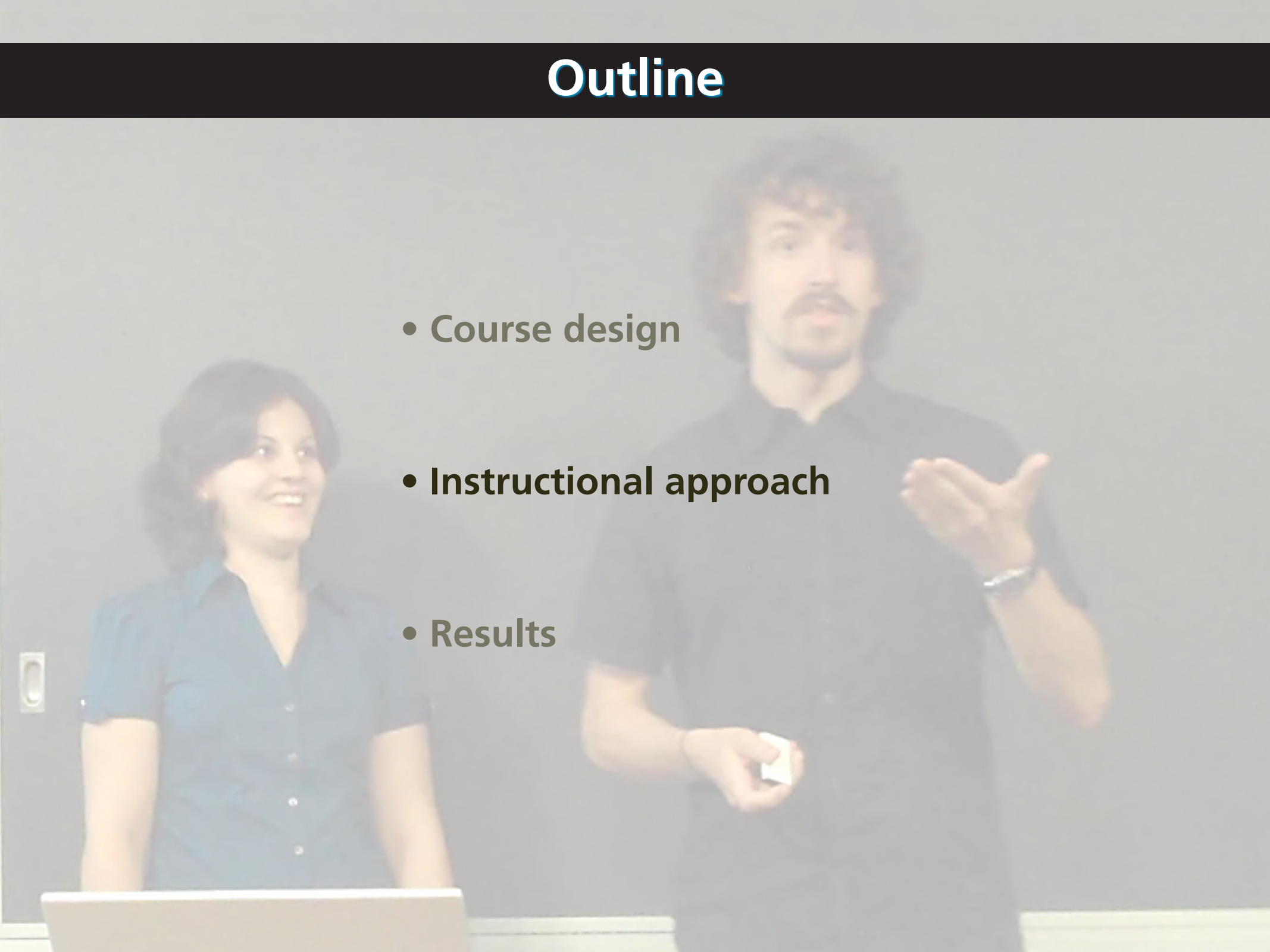
no questions 0

irrelevant question 1

clarification or comment 2

trigger for group discussion 3

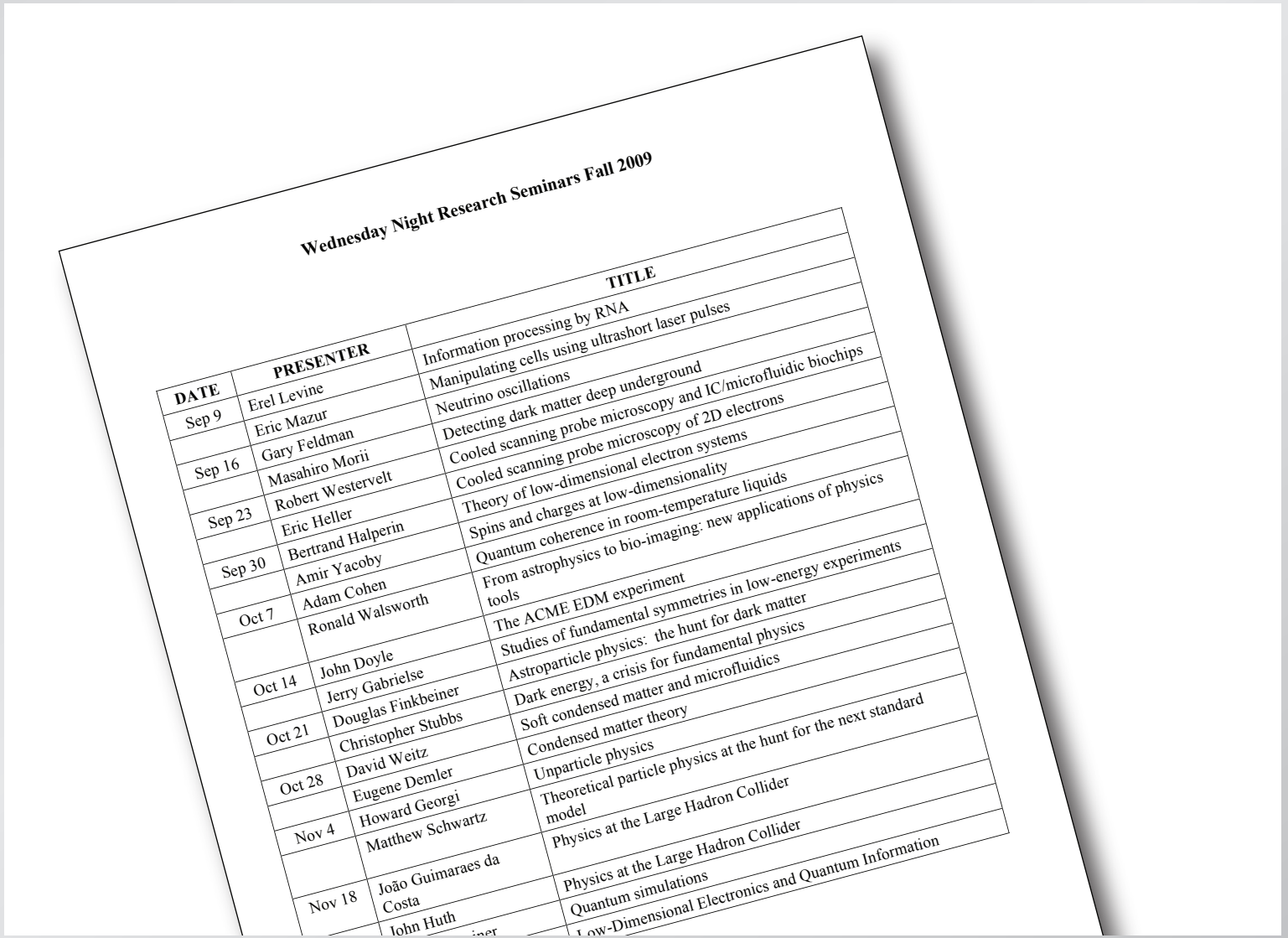
Outline



- Course design
- **Instructional approach**
- Results

Instructional approach

semester schedule



Wednesday Night Research Seminars Fall 2009

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	Eric Mazur	Manipulating cells using ultrashort laser pulses
Sep 16	Gary Feldman	Neutrino oscillations
	Masahiro Morii	Detecting dark matter deep underground
Sep 23	Robert Westervelt	Cooled scanning probe microscopy and IC/microfluidic biochips
	Eric Heller	Cooled scanning probe microscopy of 2D electrons
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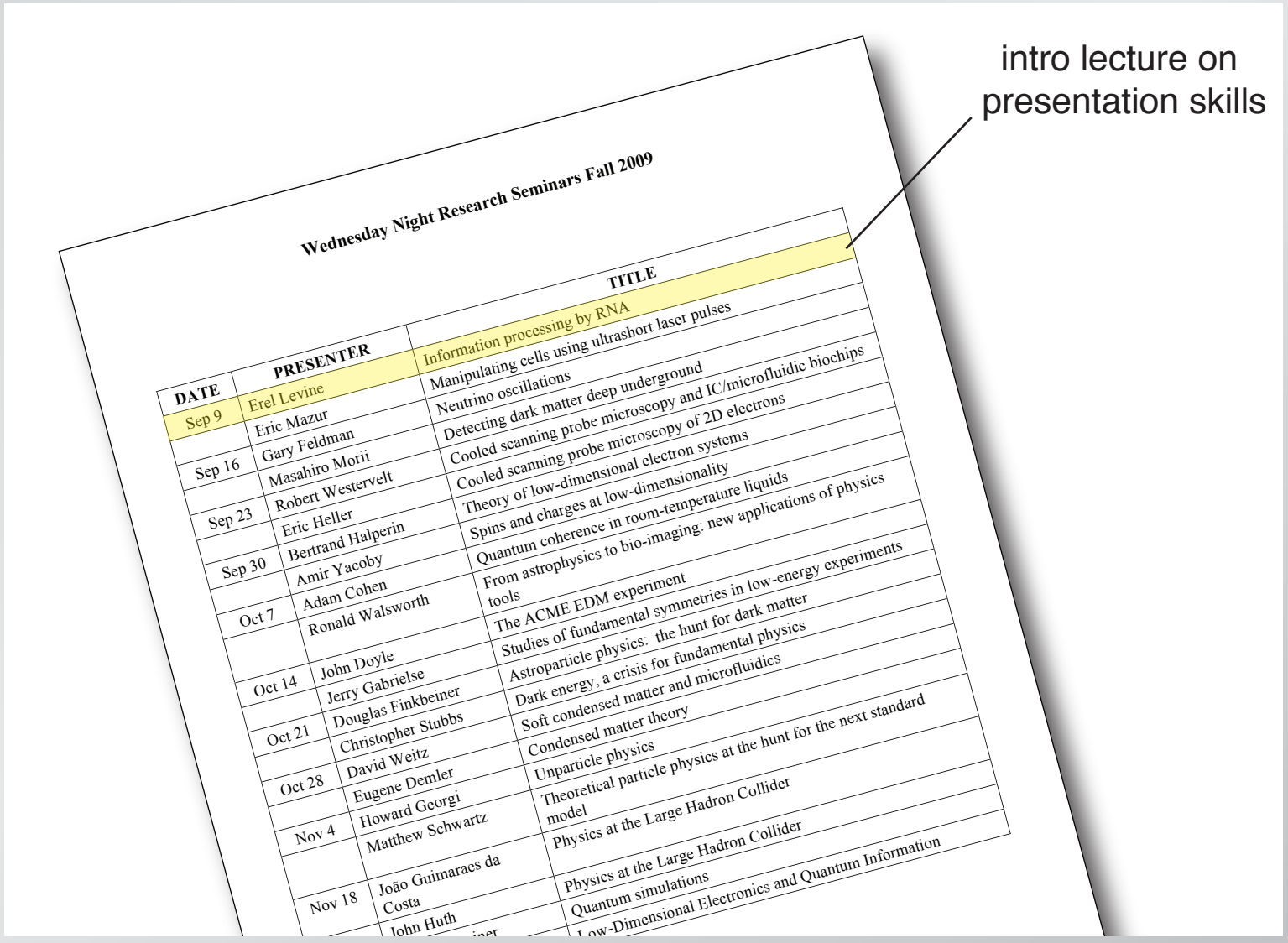
	John Huth	Physics at the Large Hadron Collider
	[illegible]iner	Quantum simulations
		Low-Dimensional Electronics and Quantum Information

Instructional approach

semester schedule



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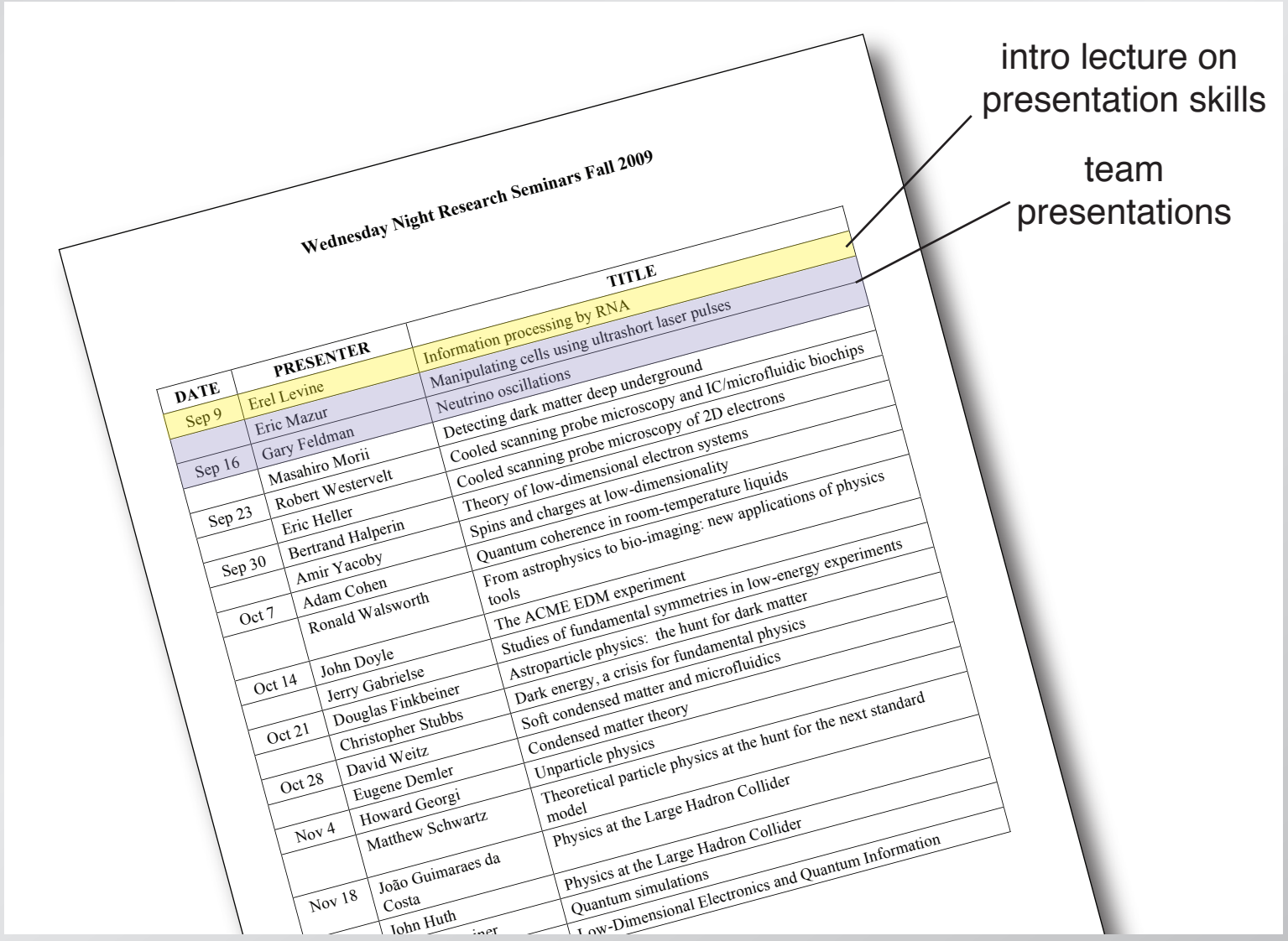
intro lecture on presentation skills

Instructional approach

semester schedule



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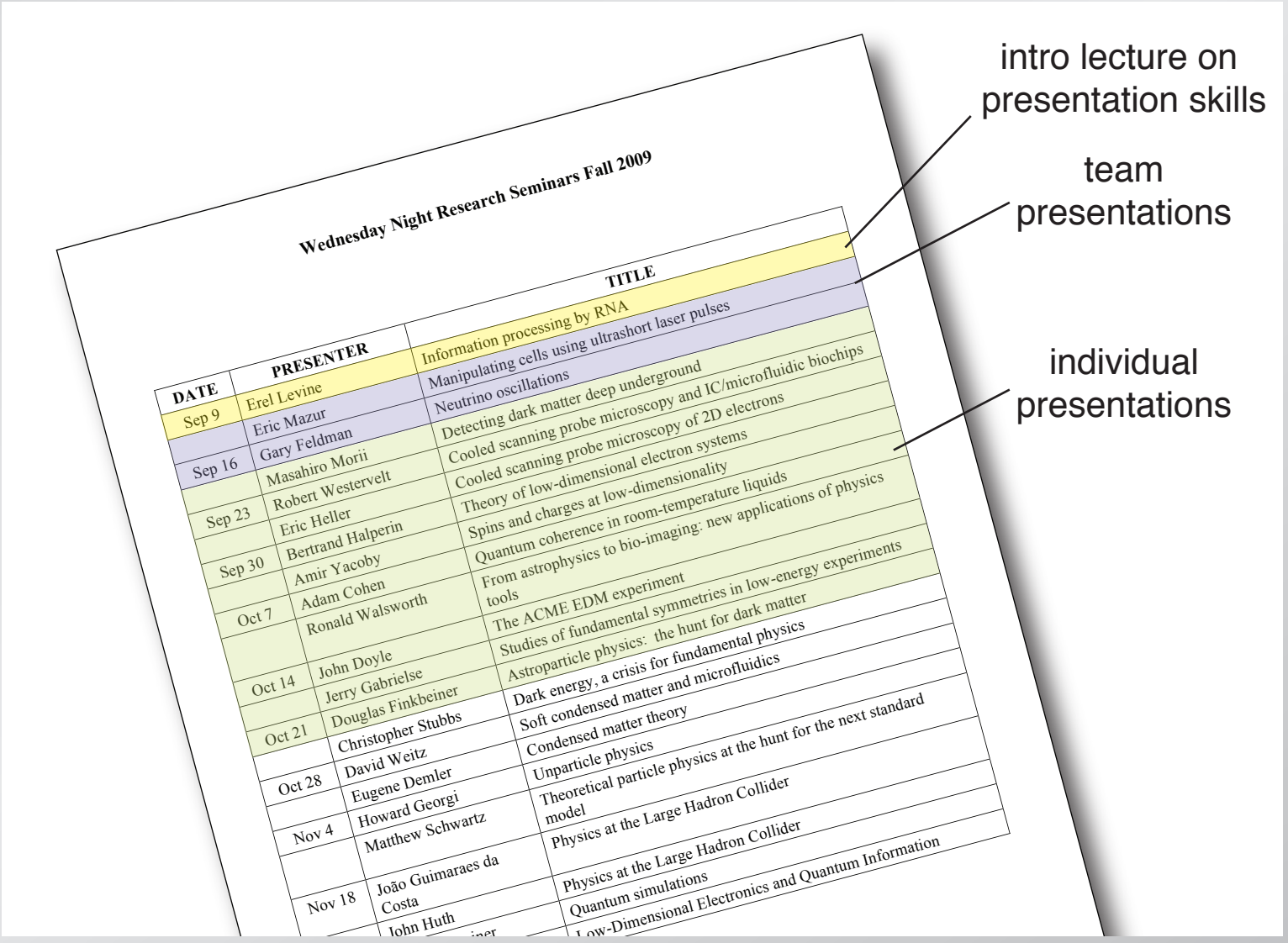
team presentations

Instructional approach

semester schedule



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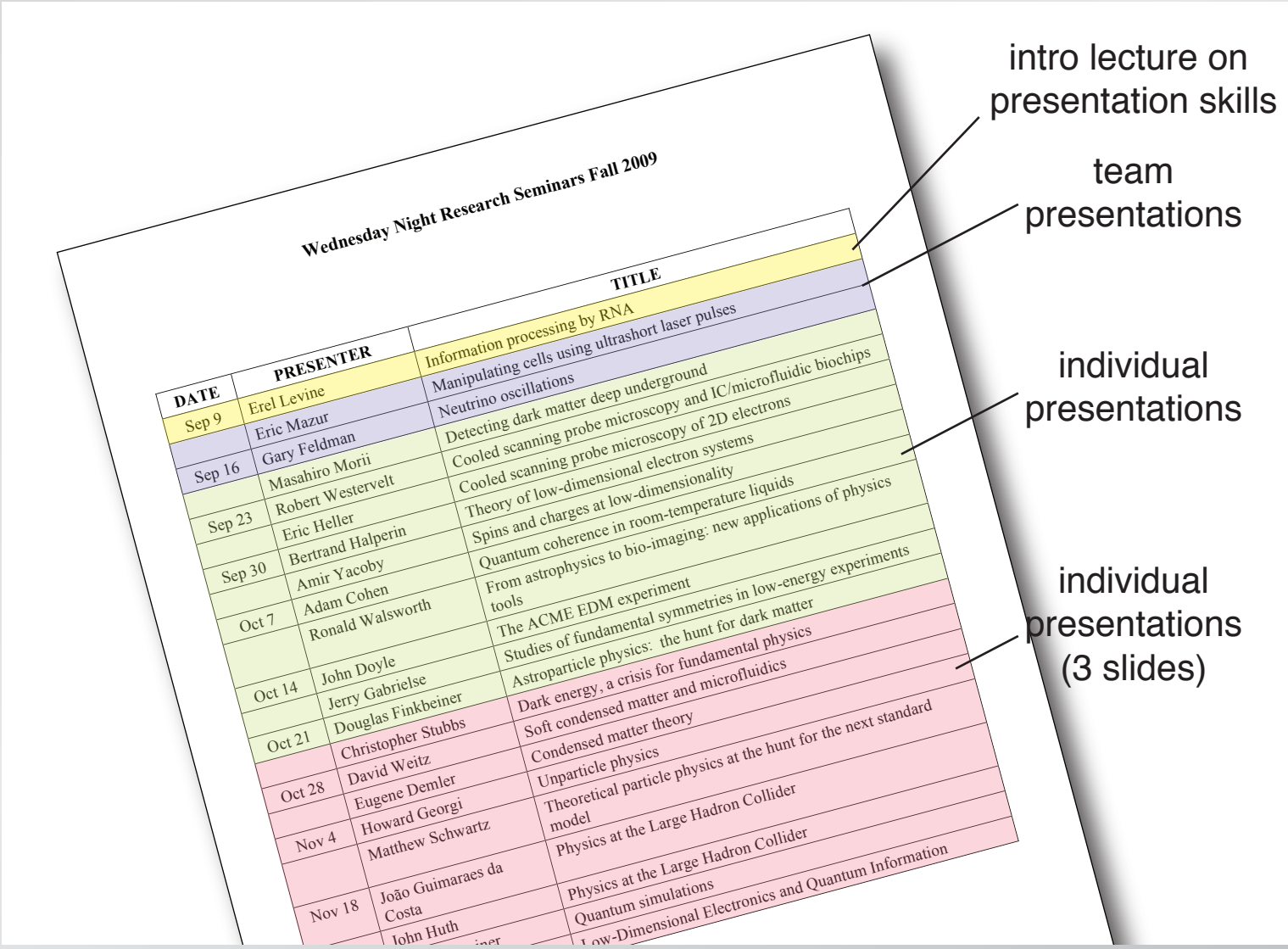
intro lecture on presentation skills

team presentations

individual presentations

Instructional approach

semester schedule



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intro lecture on presentation skills

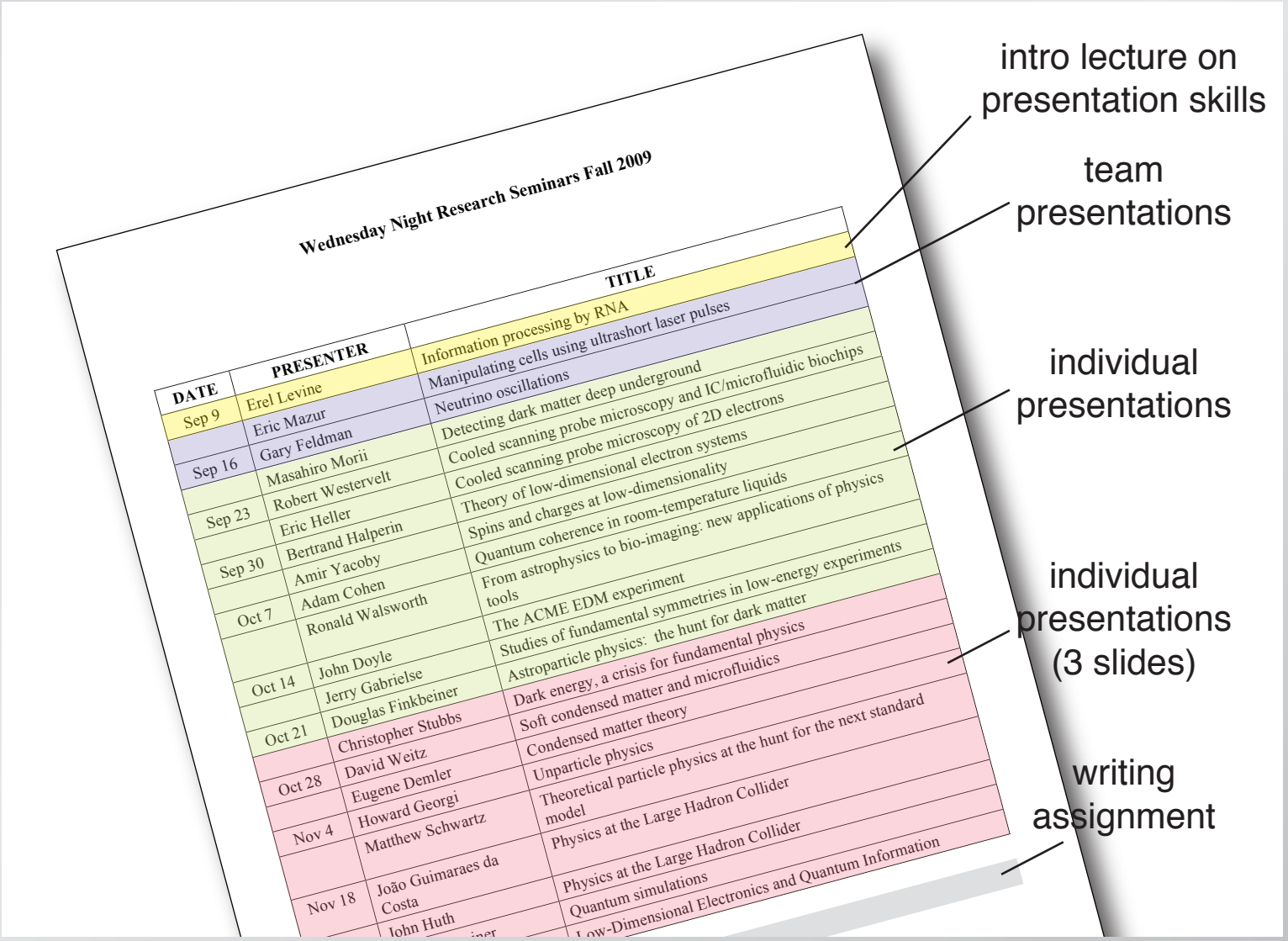
team presentations

individual presentations

individual presentations (3 slides)

Instructional approach

semester schedule



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intro lecture on presentation skills

team presentations

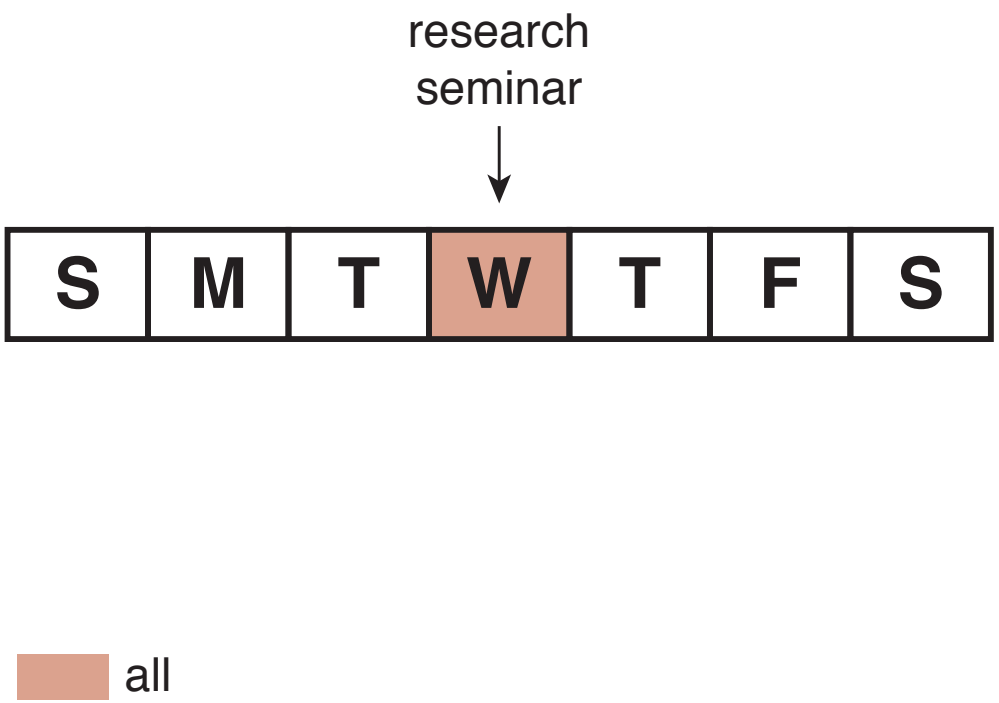
individual presentations

individual presentations (3 slides)

writing assignment

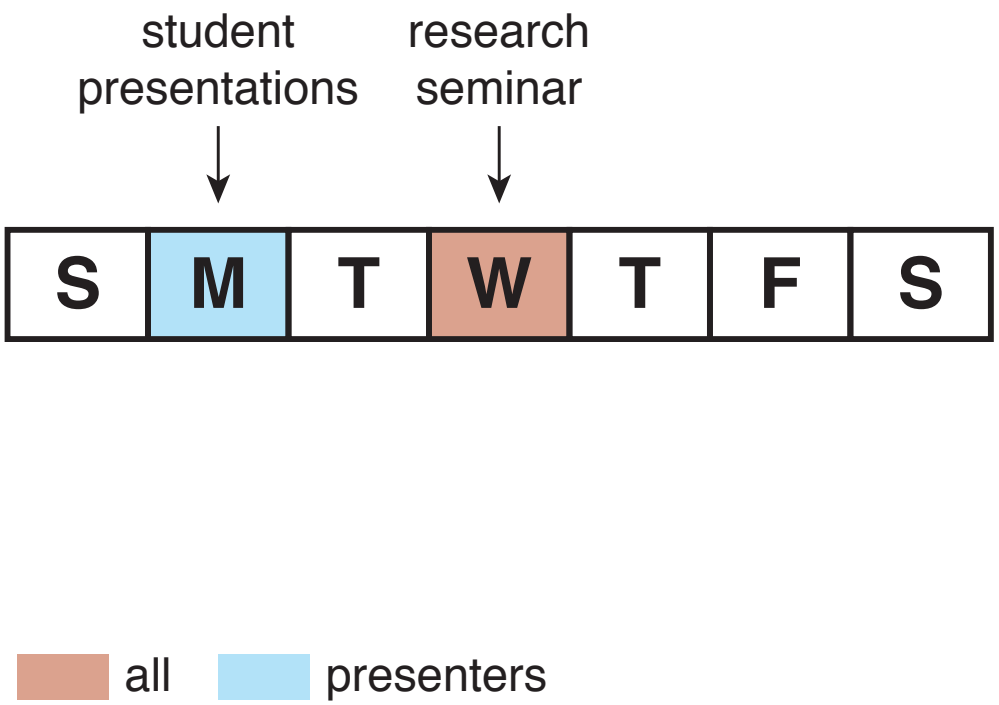
Instructional approach

weekly schedule



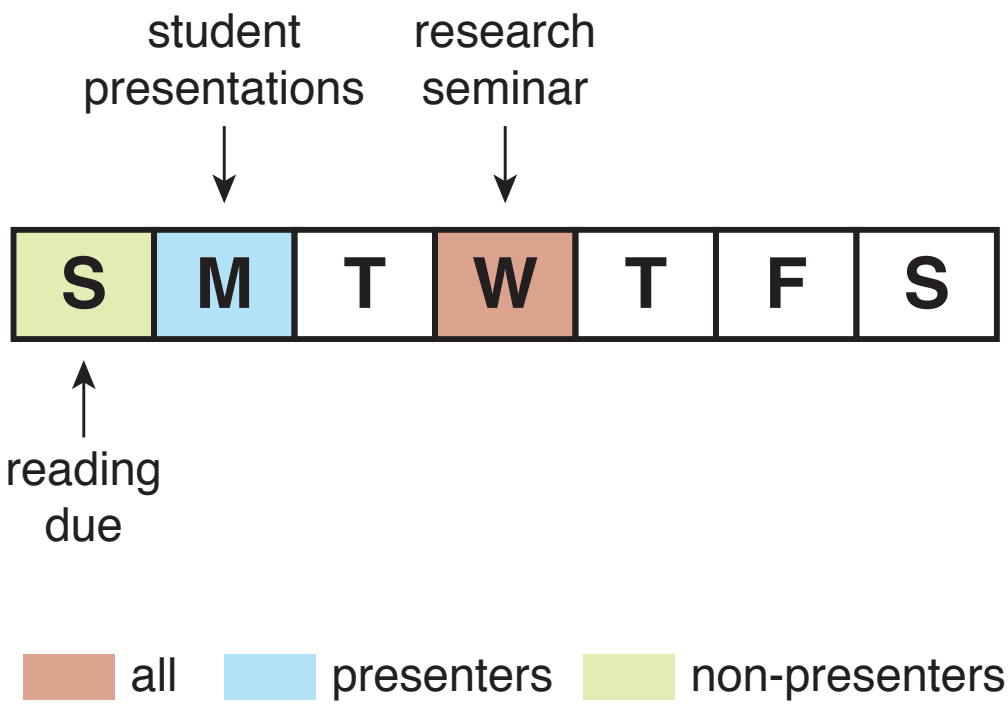
Instructional approach

weekly schedule



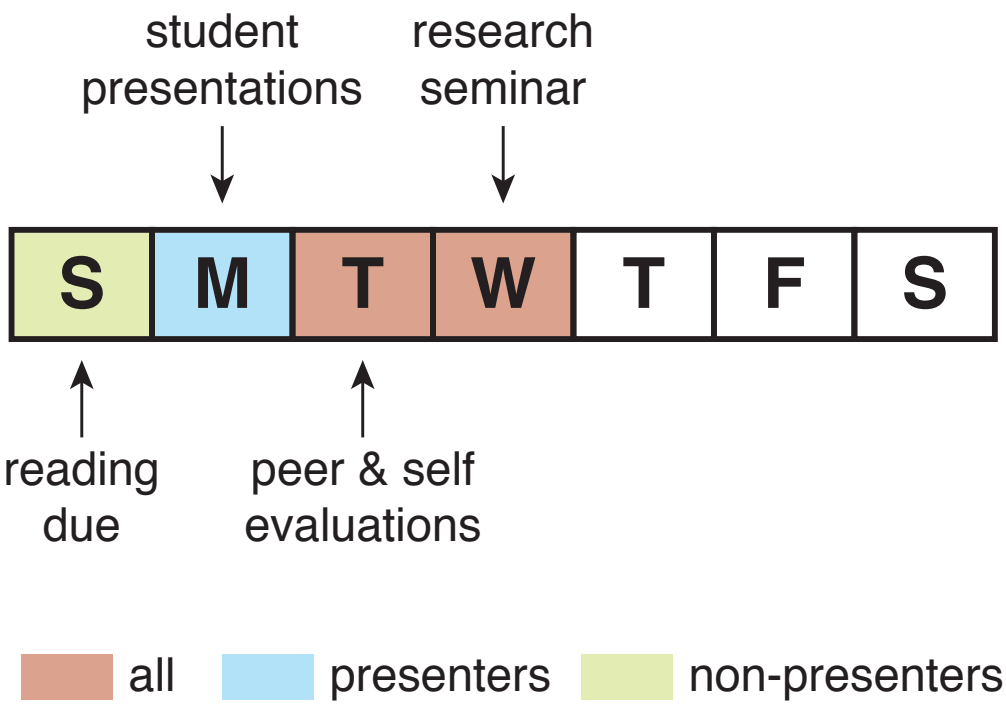
Instructional approach

weekly schedule



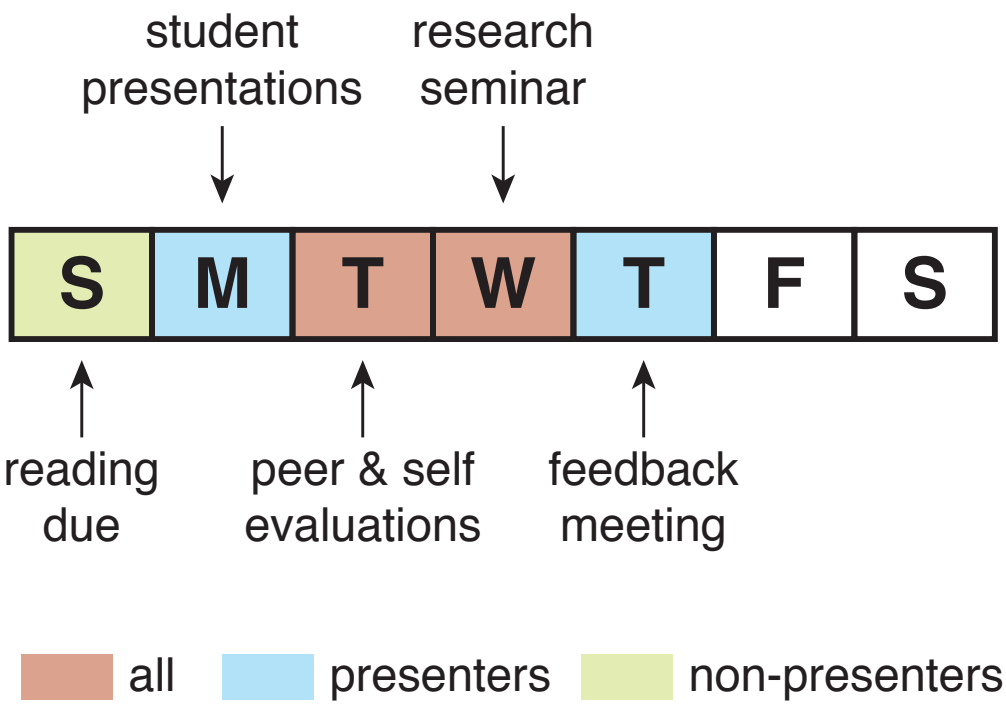
Instructional approach

weekly schedule



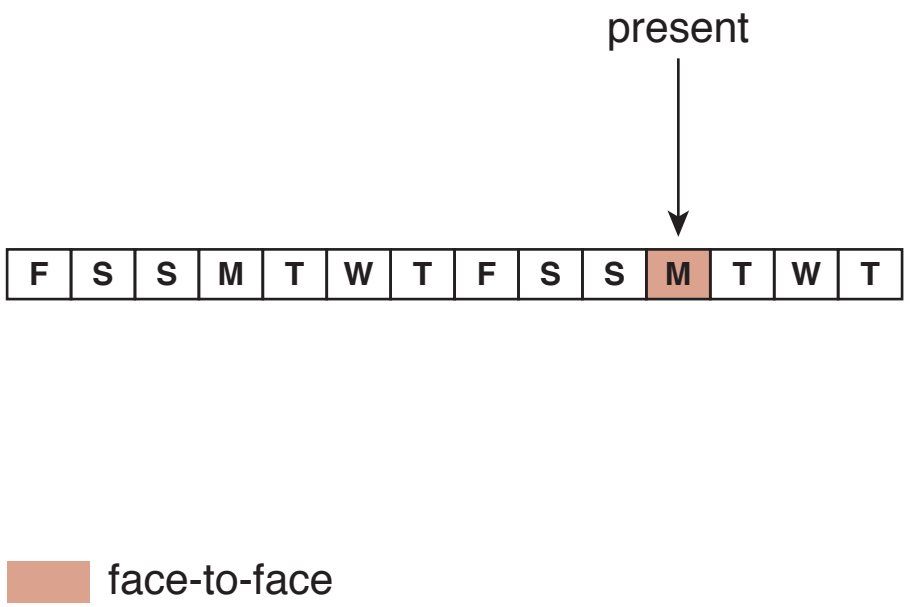
Instructional approach

weekly schedule



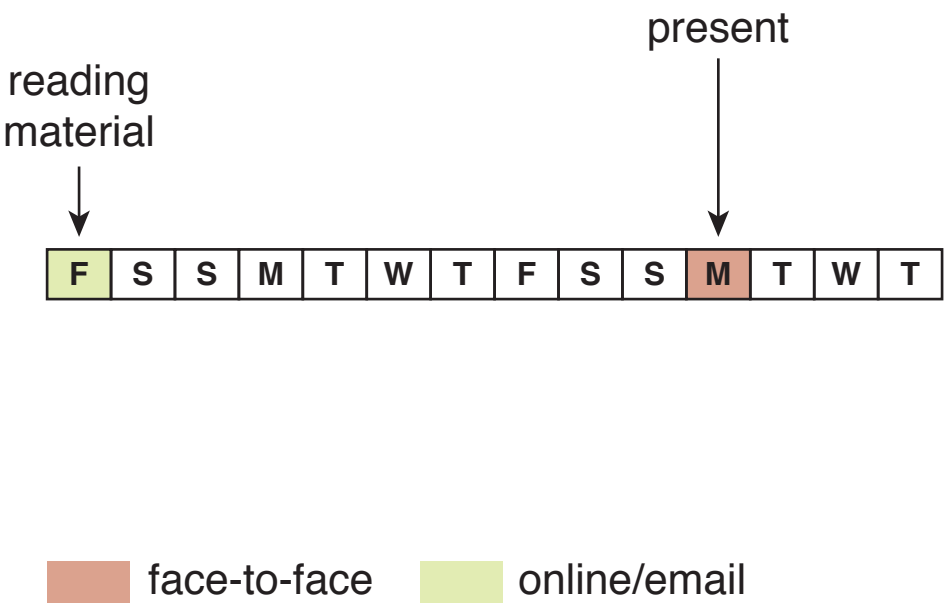
Instructional approach

presentation workflow



Instructional approach

presentation workflow



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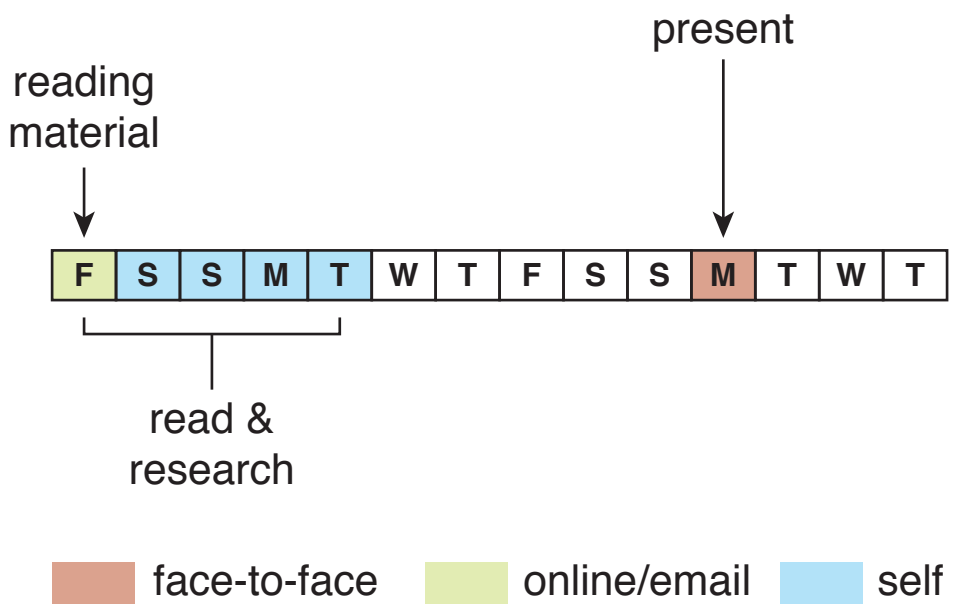

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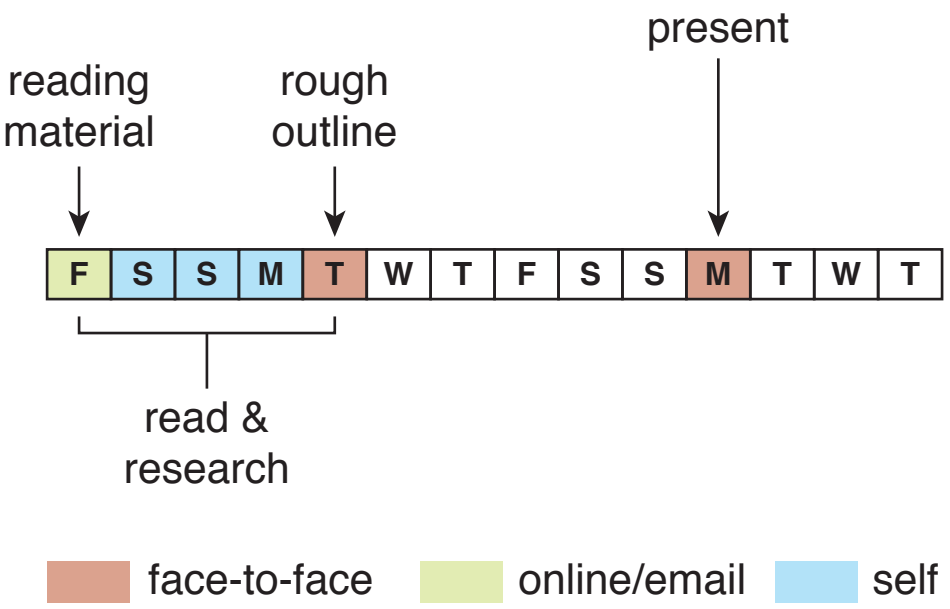
presentation workflow



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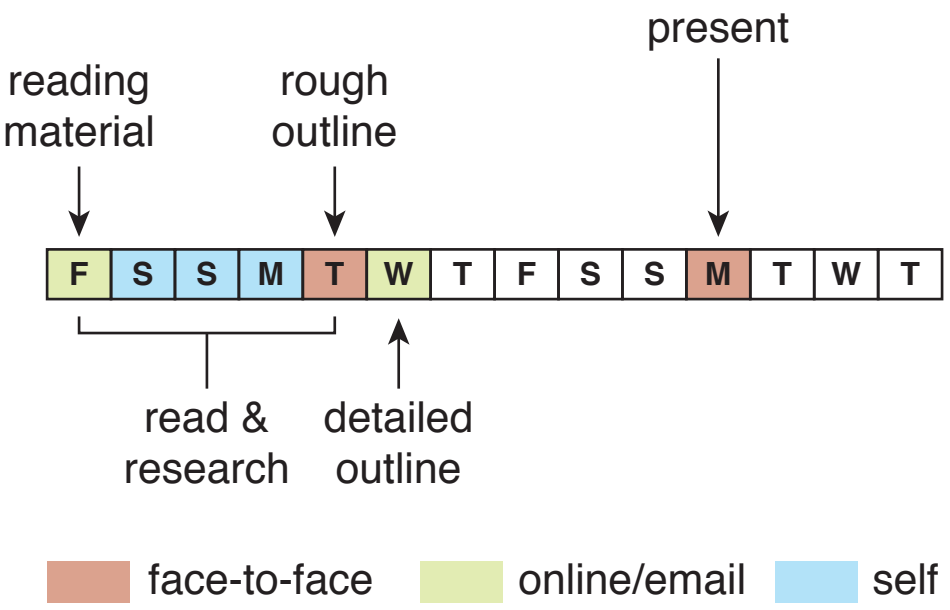

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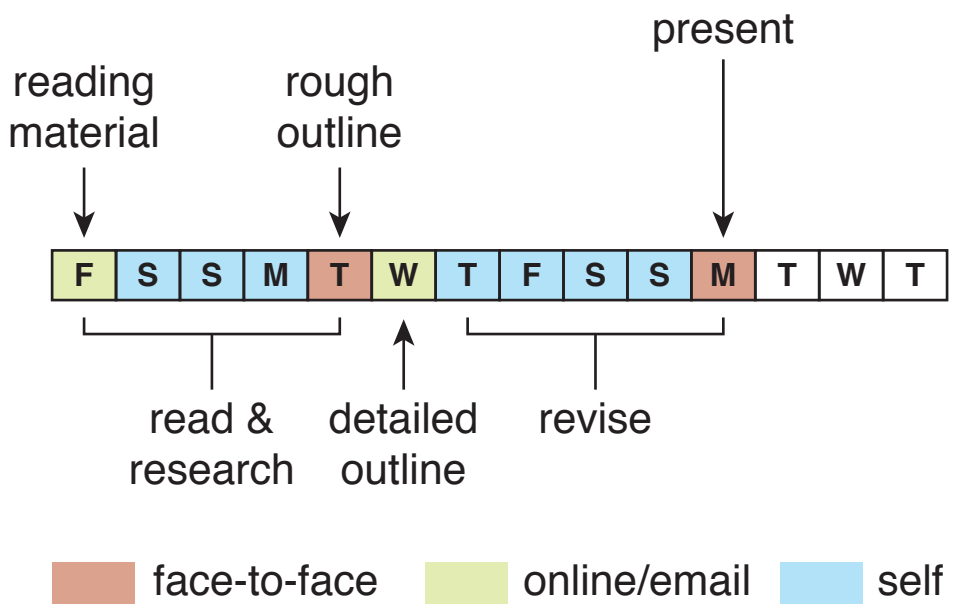

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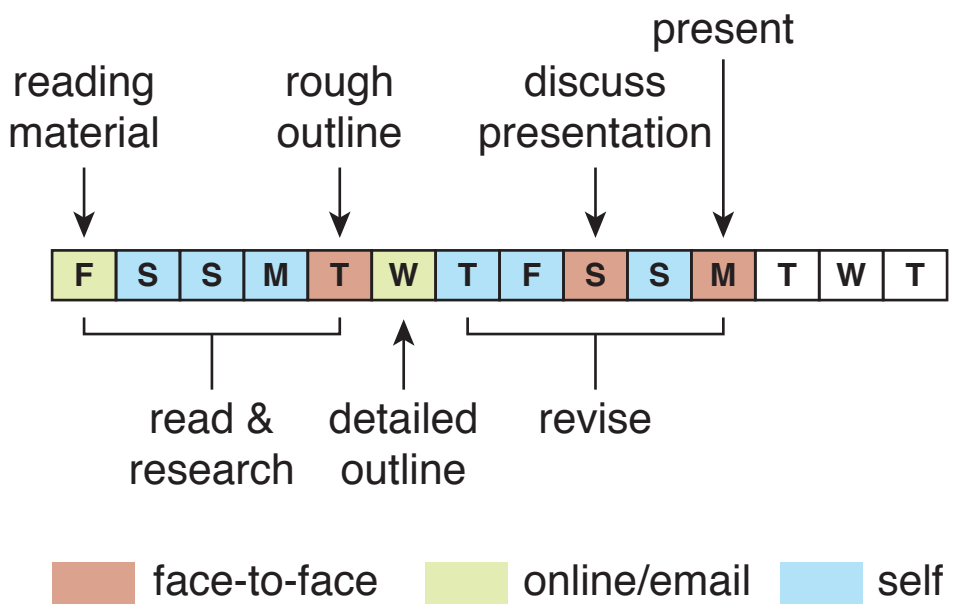

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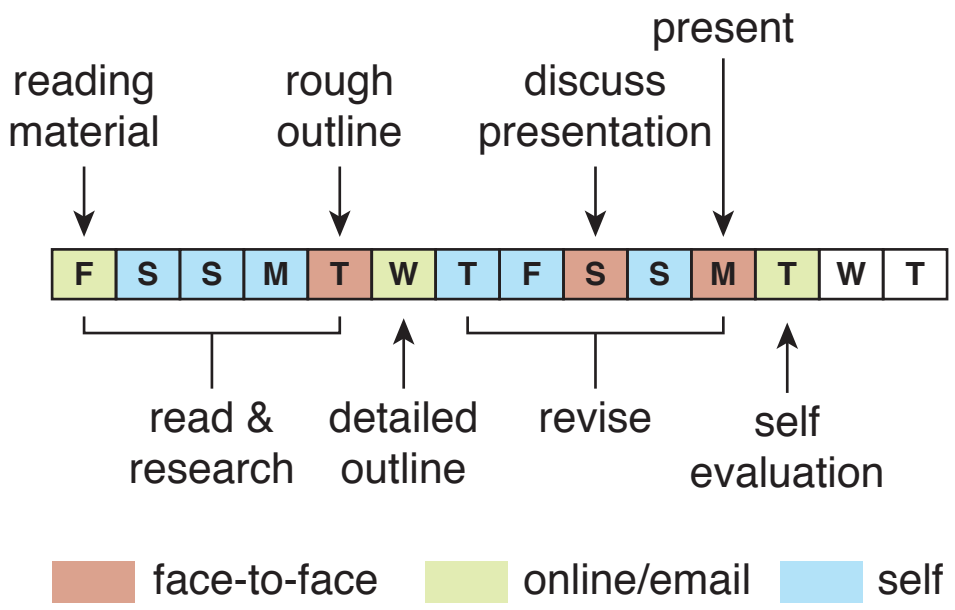

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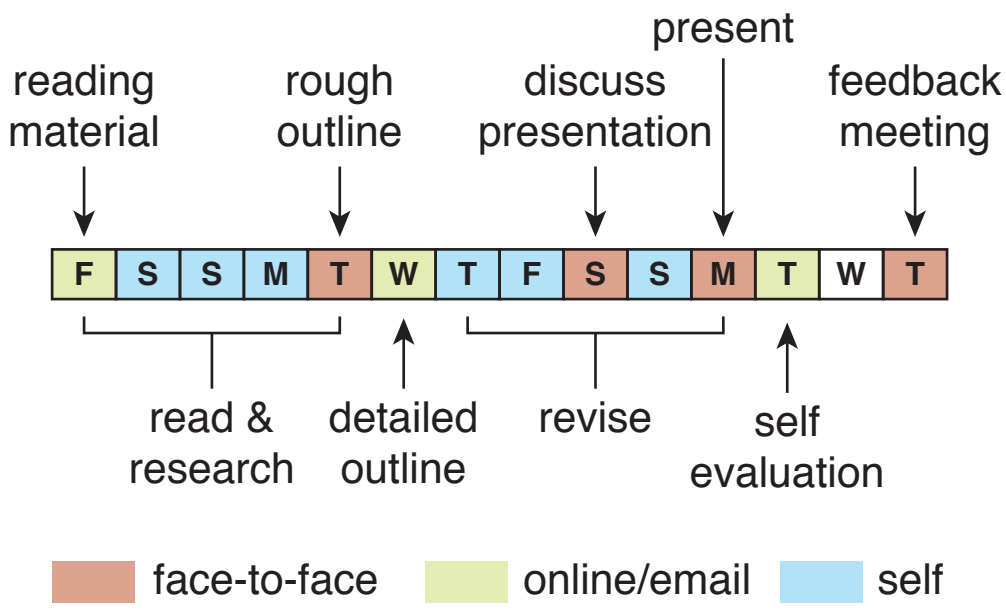

Instructional approach

feedback meeting

- review video
- discuss self, peer, and instructor evaluations
- score questions asked

Instructional approach

written communication skills

- physics content: gamma-ray bursts
- audience: non-expert
- medium: newspaper article (scenario-driven)

Instructional approach

written communication skills

- physics content: gamma-ray bursts
- audience: non-expert
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scored using Calibrated Peer Review

Instructional approach

Calibrated Peer Review

- review rubric
- research and write article
- upload article
- score 3 calibrated articles
- score articles of 3 peers (anonymous)
- score own article
- review compound score

http://cpr.molsci.ucla.edu

Instructional approach

instructor activities

	traditional	seminar
preparation	lecture	
class	deliver lecture	
1-on-1 meetings	optional	
out of class grading	termpapers	

Instructional approach

instructor activities

	traditional	seminar
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Instructional approach

instructor activities

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Instructional approach

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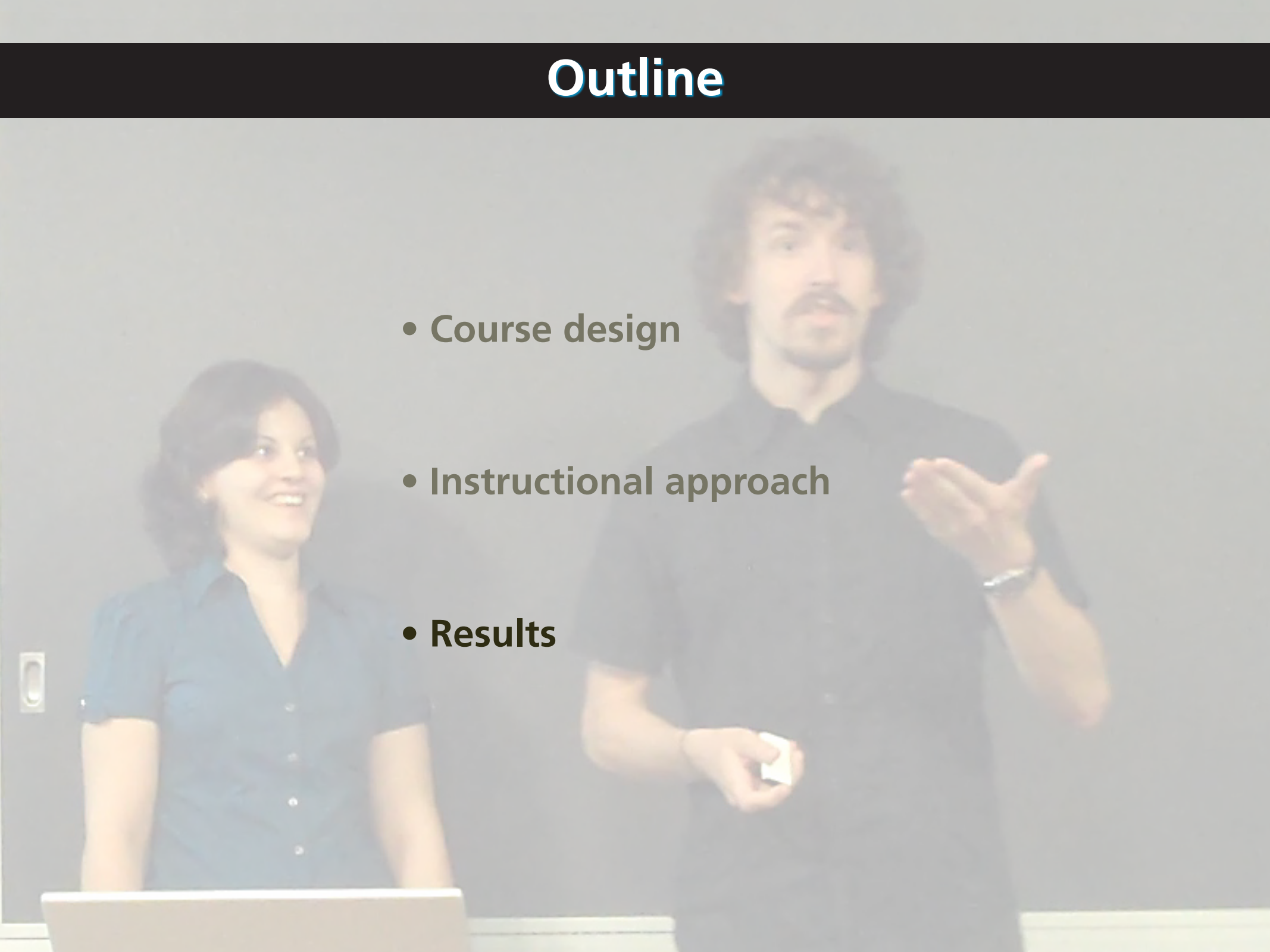
net demands on time similar (but more fun!)

Outline



- Course design
- Instructional approach
- **Results**

Results

low N $\longrightarrow$ qualitative results

Results

let’s first look at student evaluations…

Results

Overall:

"The best course I have taken at Harvard, and probably the most useful for when I leave this place."

Results

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"The best course I have taken at Harvard, and probably the most useful for when I leave this place."

"Definitely the most enjoyable physics class that I've had. I walk away actually knowing, understanding and even REMEMBERING what I'd learned."

Results

Teaching essential, useful skills:

"I learned a lot about how to present scientific ideas effectively, how to go about learning a new scientific topic quickly (which I'm sure will be useful in future endeavors)."

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"Really important and rare opportunity to develop essential skills that you don't learn in other physics classes."

Results

Learning happens:

"Wonderful class — you'll learn more in this class than many of the other physics classes at Harvard."

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"If you don't understand something, you HAVE to push yourself to understand. Half-ass explanations just seldom work."

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Learning happens:

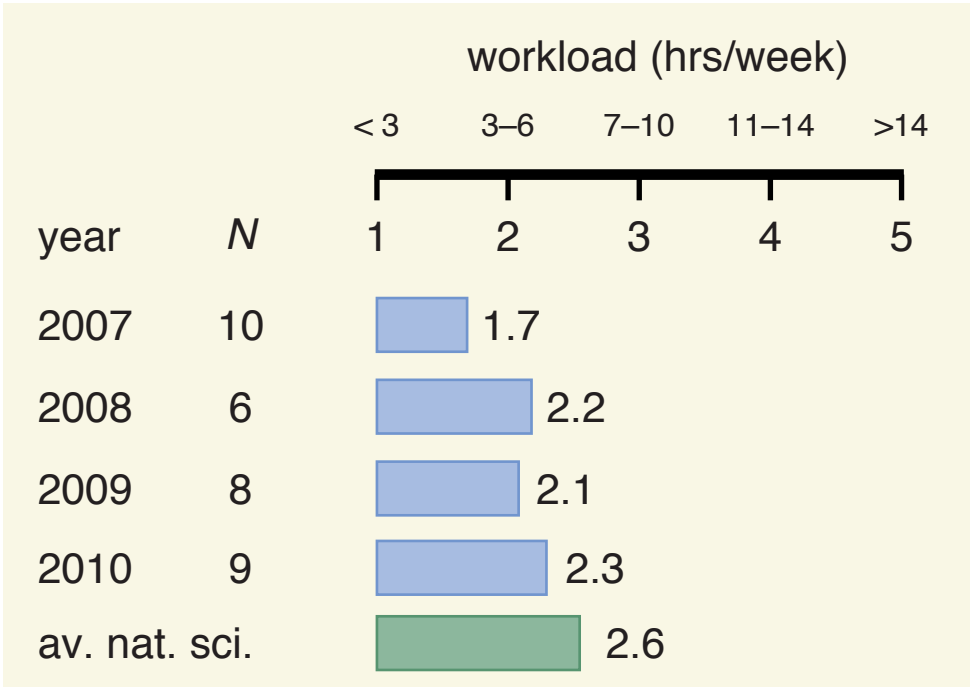
"Wonderful class — you'll learn more in this class than many of the other physics classes at Harvard."

"If you don't understand something, you HAVE to push yourself to understand. Half-ass explanations just seldom work."

"One of the few courses I've taken where the amount learned doesn't match the difficulty of the work."

Results

workload



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Physics still center stage:

"I have a better appreciation for the field of physics in general, and am much more informed regarding what current research is going on in physics today."

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"I have a better appreciation for the field of physics in general, and am much more informed regarding what current research is going on in physics today."

"I learned much more physics in this course than I have in other courses"

"This course allows you to actually think like a physicist about topics like how to solve a challenging problem or what are important questions in modern research."

Results

student vs. instructor evaluations

	students	instructor
round 1	67.4%	68.2%
round 2	70.7%	71.1%
round 3	69.7%	73.2%
course	69.2%	71.4%

Results

questions asked

year	1	2	3	total	to peers	to faculty
2008	0	83	37	120	66	54
2009	0	144	22	166	71	95
2010	21	67	19	166	65	42

Results

have we accomplished the learning objectives?

Results

After course, will be able to

- draw on broad knowledge base in current physics
- research new (and unfamiliar) topics
- participate in discussions with peers and experts
- design and deliver effective presentations
- write scientific article for non-science audience
- evaluate your own and others' work

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After course, will be able to

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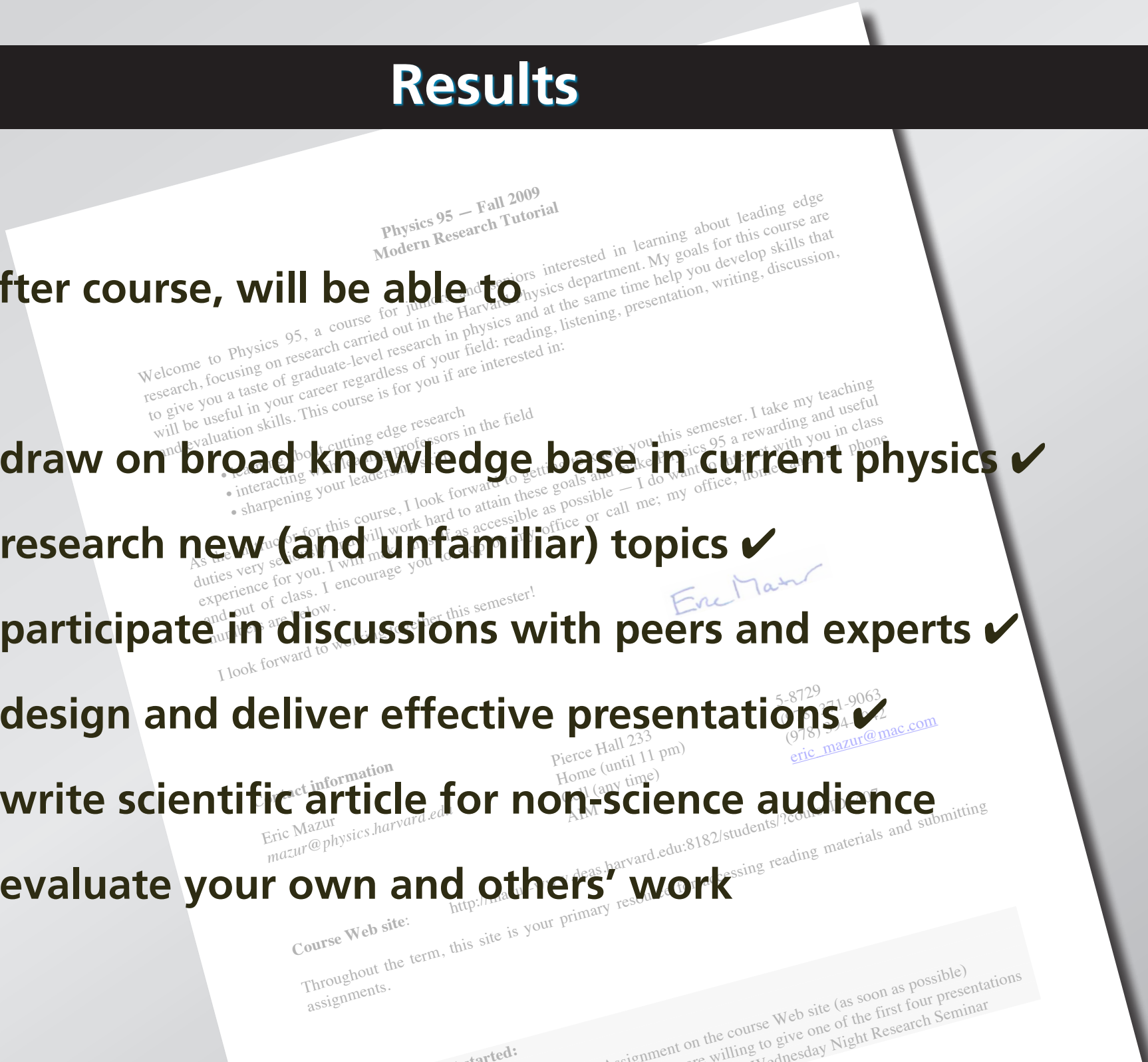

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Conclusions

- effectively teach communication skills
- content learned in spite of focus on skills

Funding:

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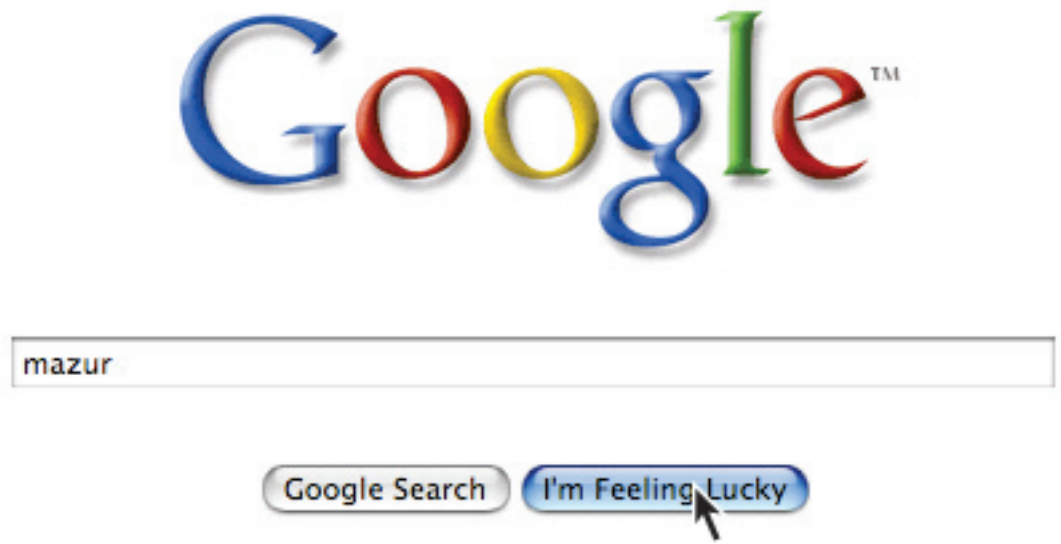
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