

Using seminar-based instruction to convey contemporary research to undergraduates



Gordon Research Conference
on Physics Research & Education
South Hadley, MA, 10 June 2010



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

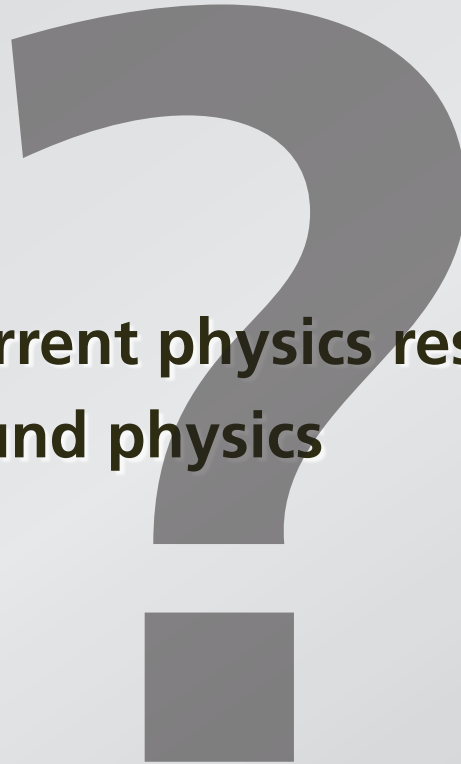
Outcome



Introduction

Outcome

- ideas about current physics research
- some background physics



Introduction

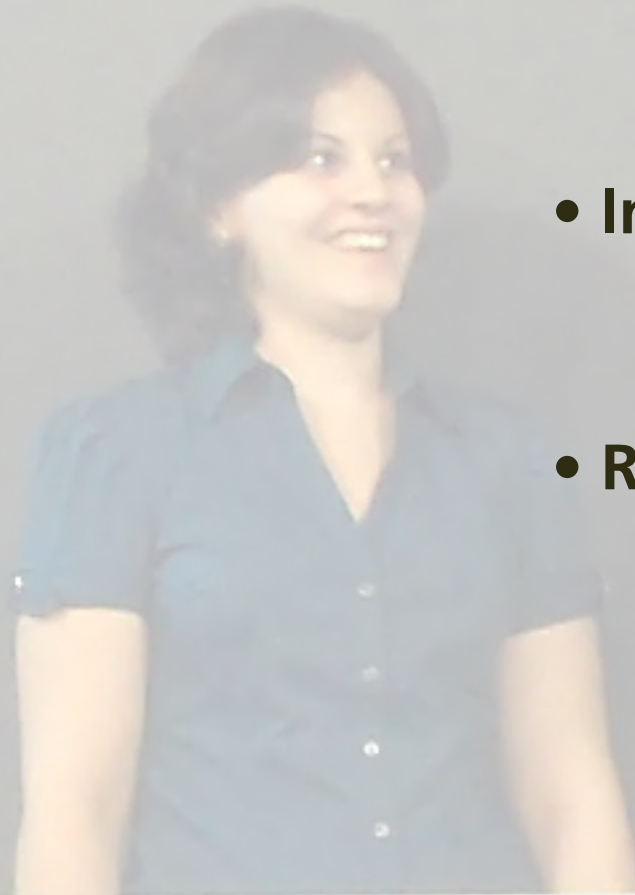
Outcome

- 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?

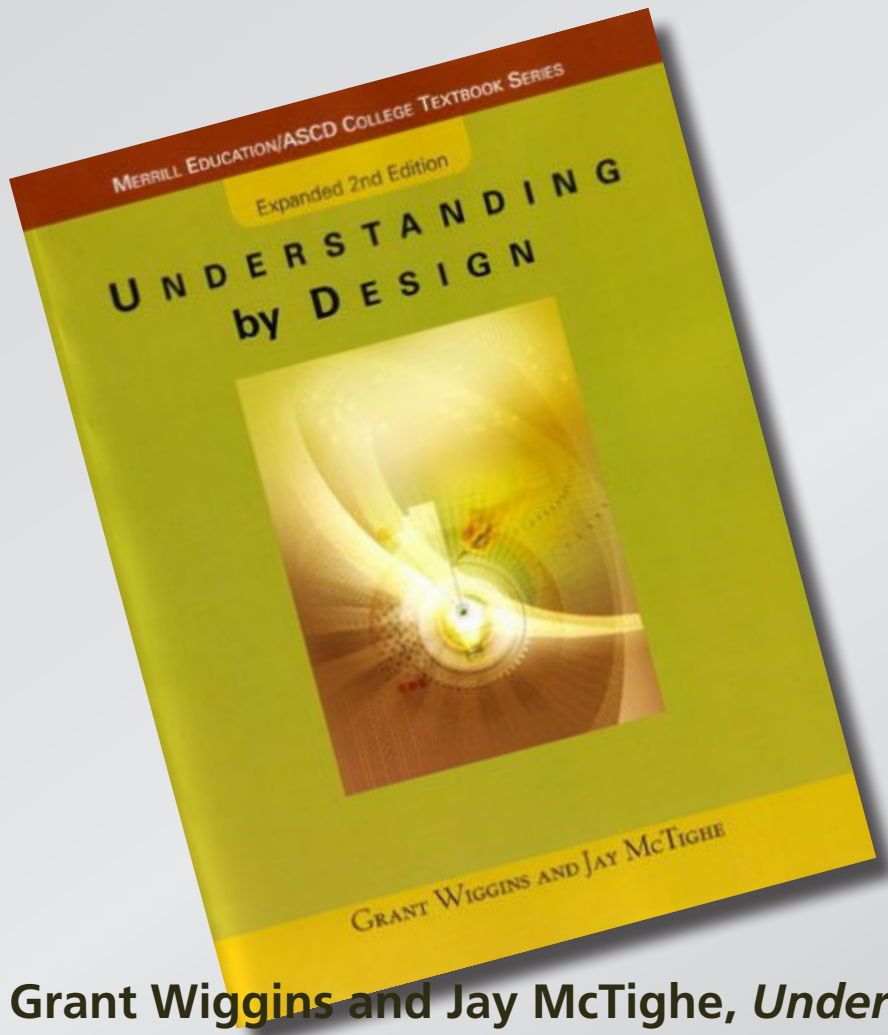
Course design

how to keep non-presenters engaged?

evaluate on discussion skills

Course design

Setting learning goals

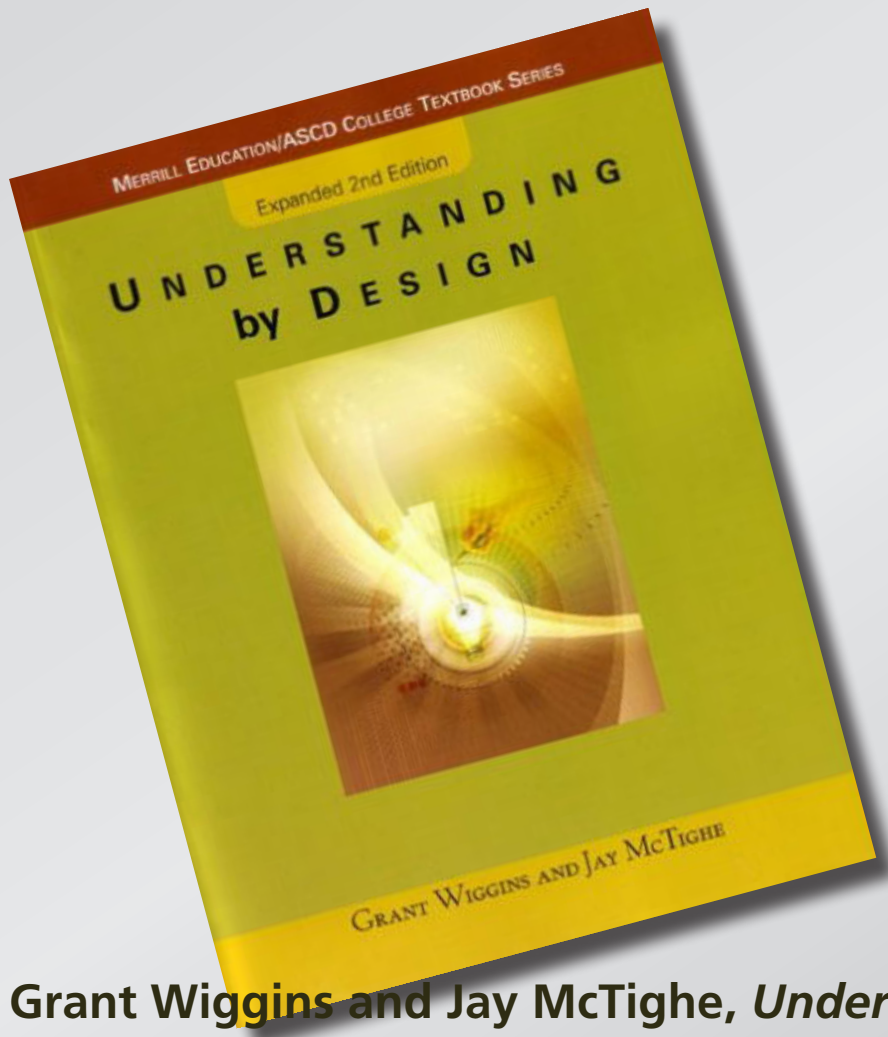


Grant Wiggins and Jay McTighe, *Understanding by Design* (Prentice Hall, 2001)

Course design

Setting learning goals

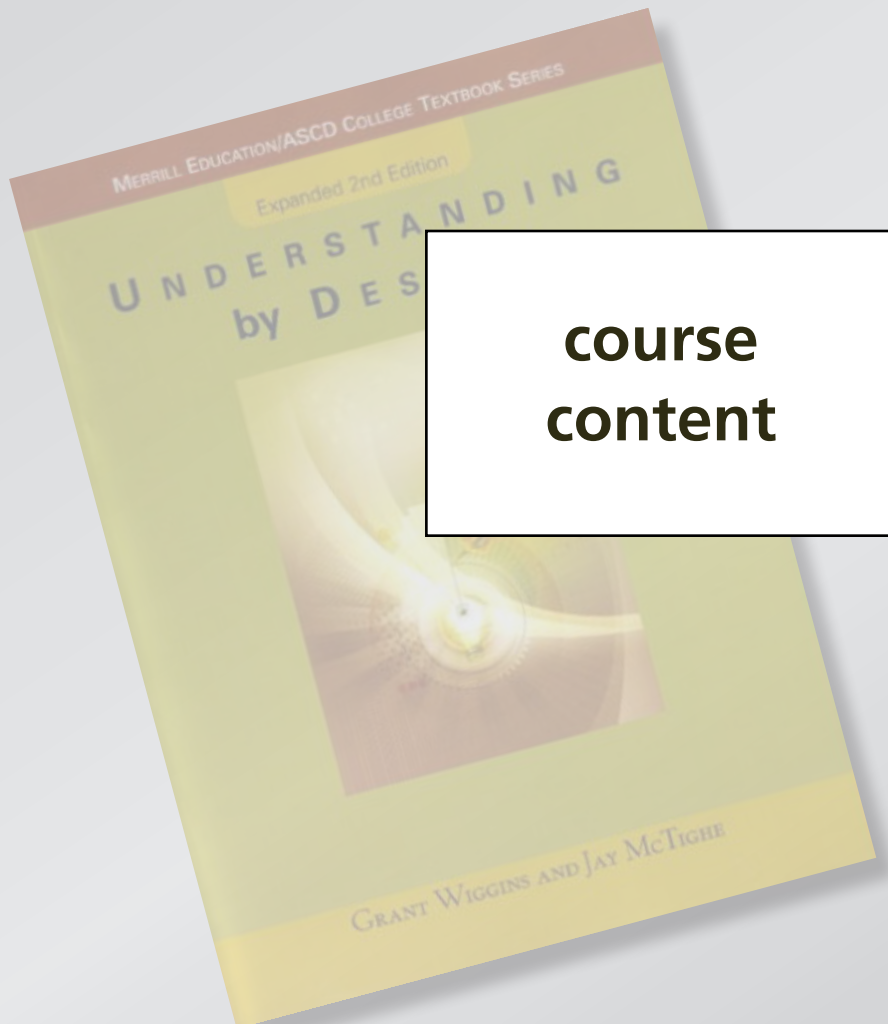
- approach, not content
- focus on understanding
- backward design



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

Course design

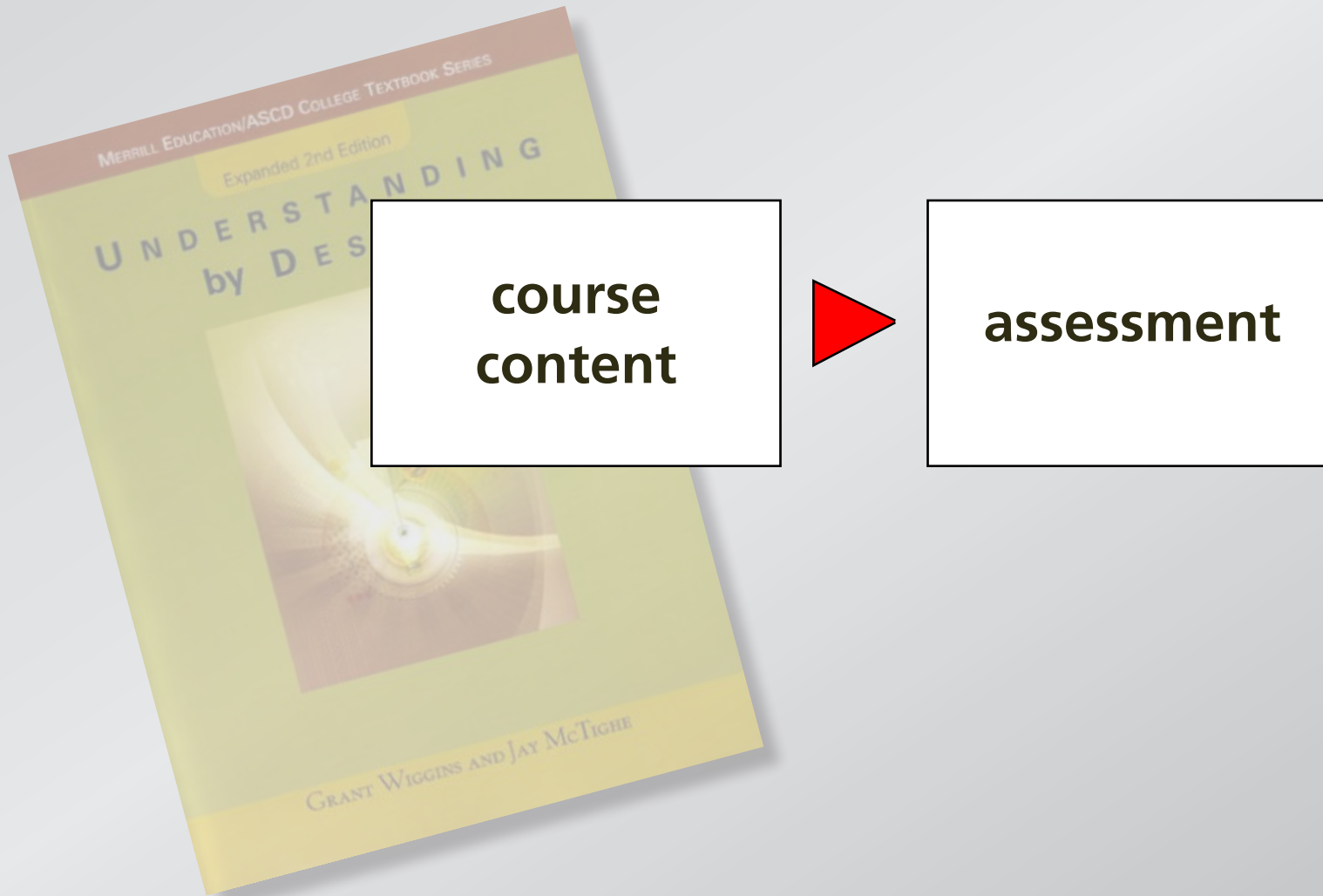
Traditional approach to course planning



**course
content**

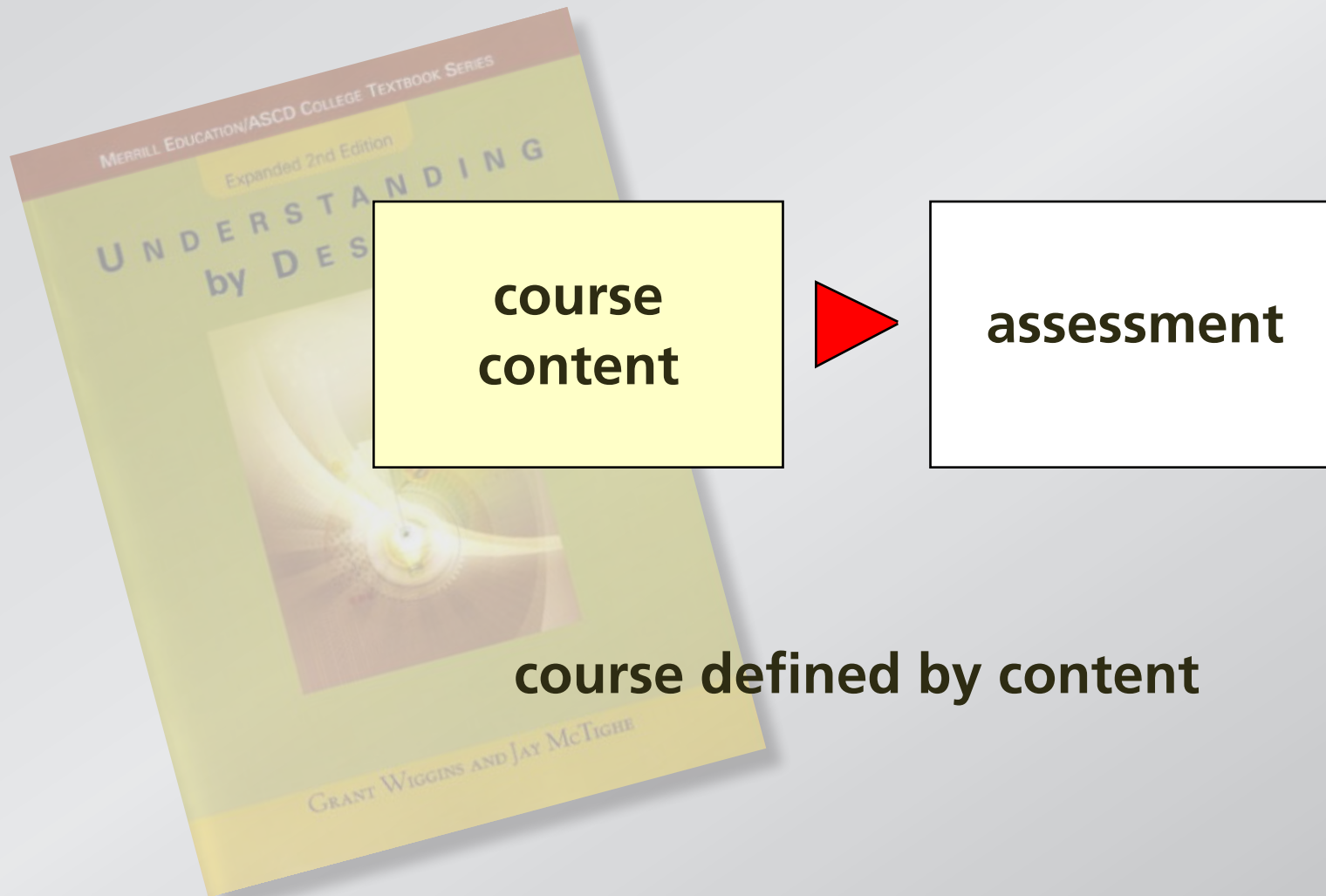
Course design

Traditional approach to course planning



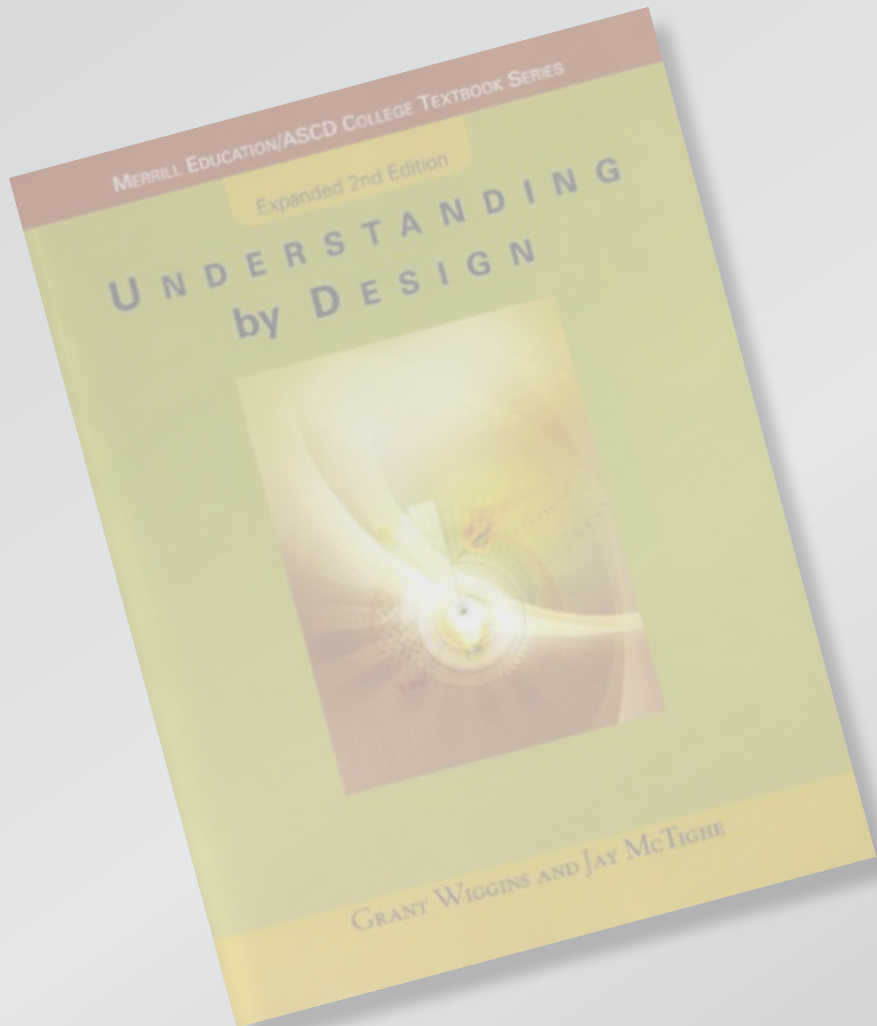
Course design

Traditional approach to course planning



Course design

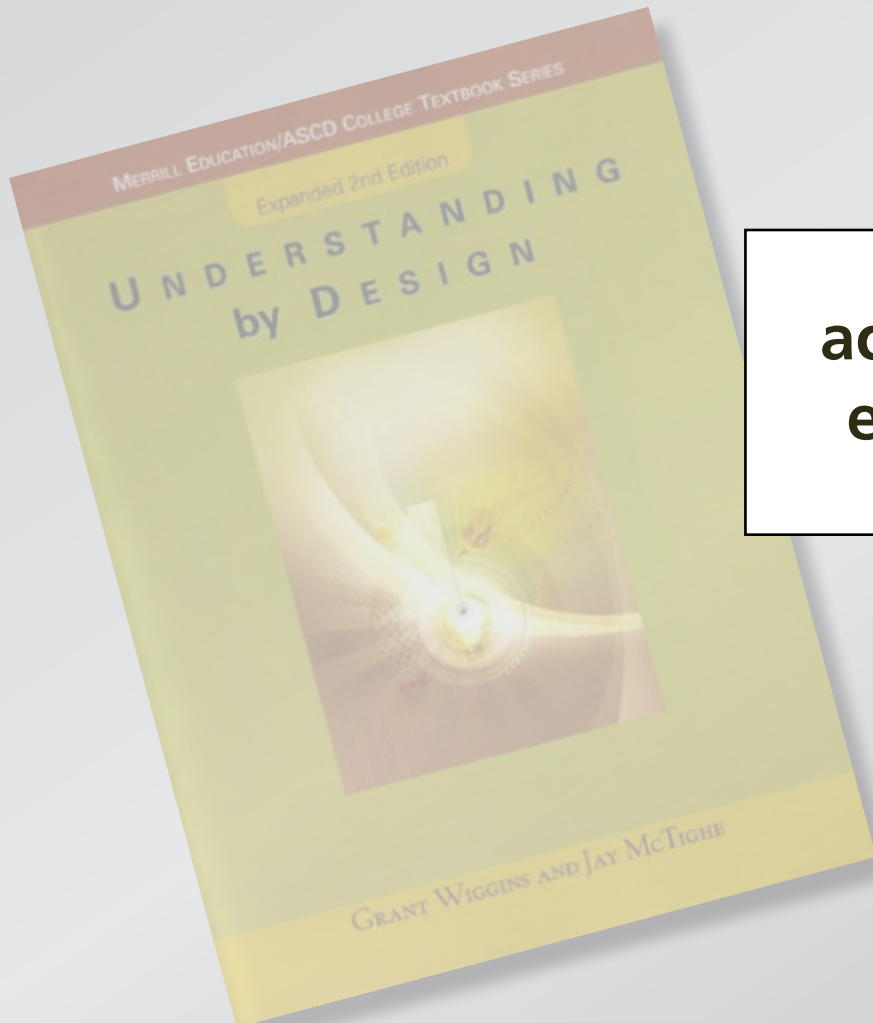
Backward design



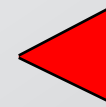
**desired
outcomes**

Course design

Backward design



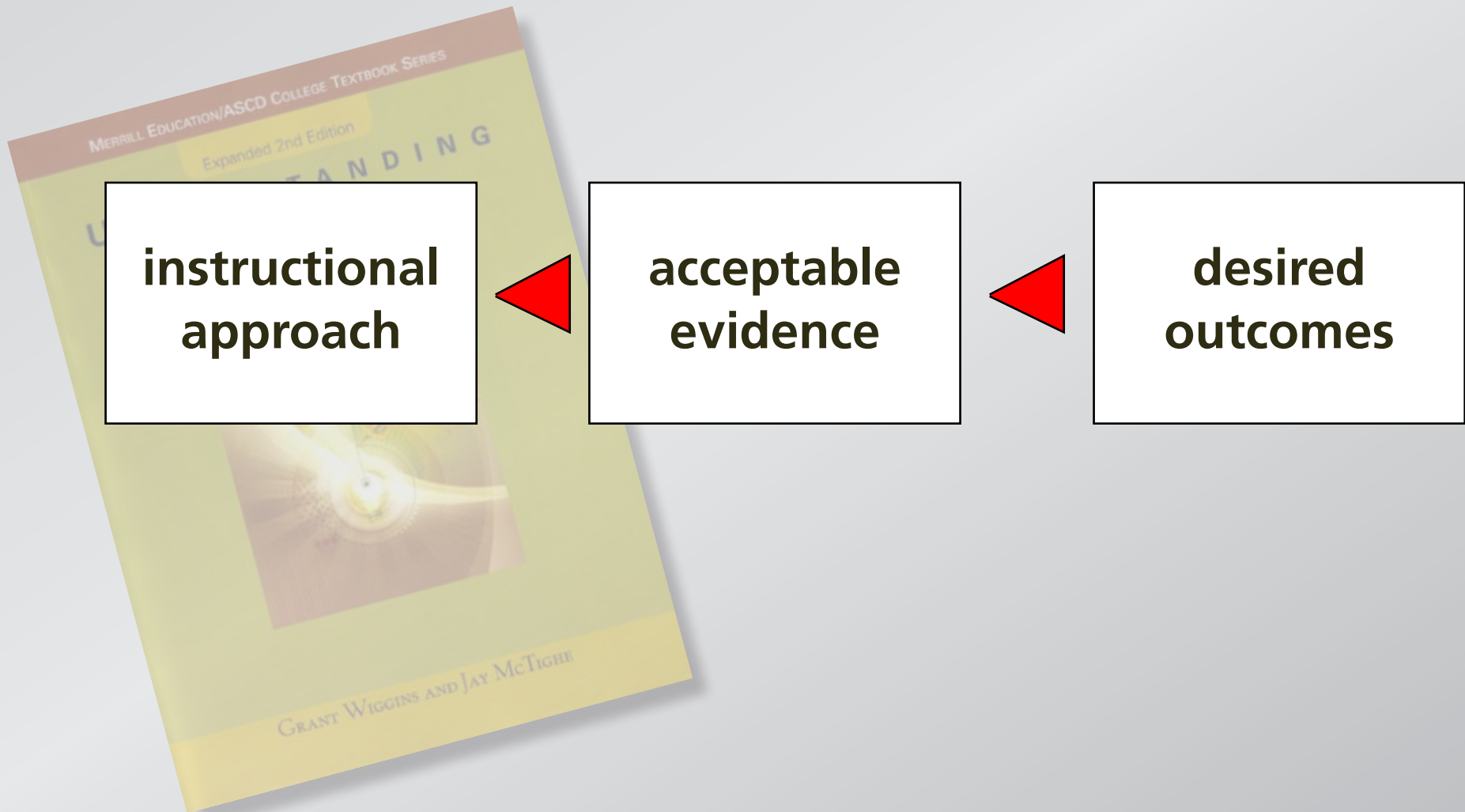
**acceptable
evidence**



**desired
outcomes**

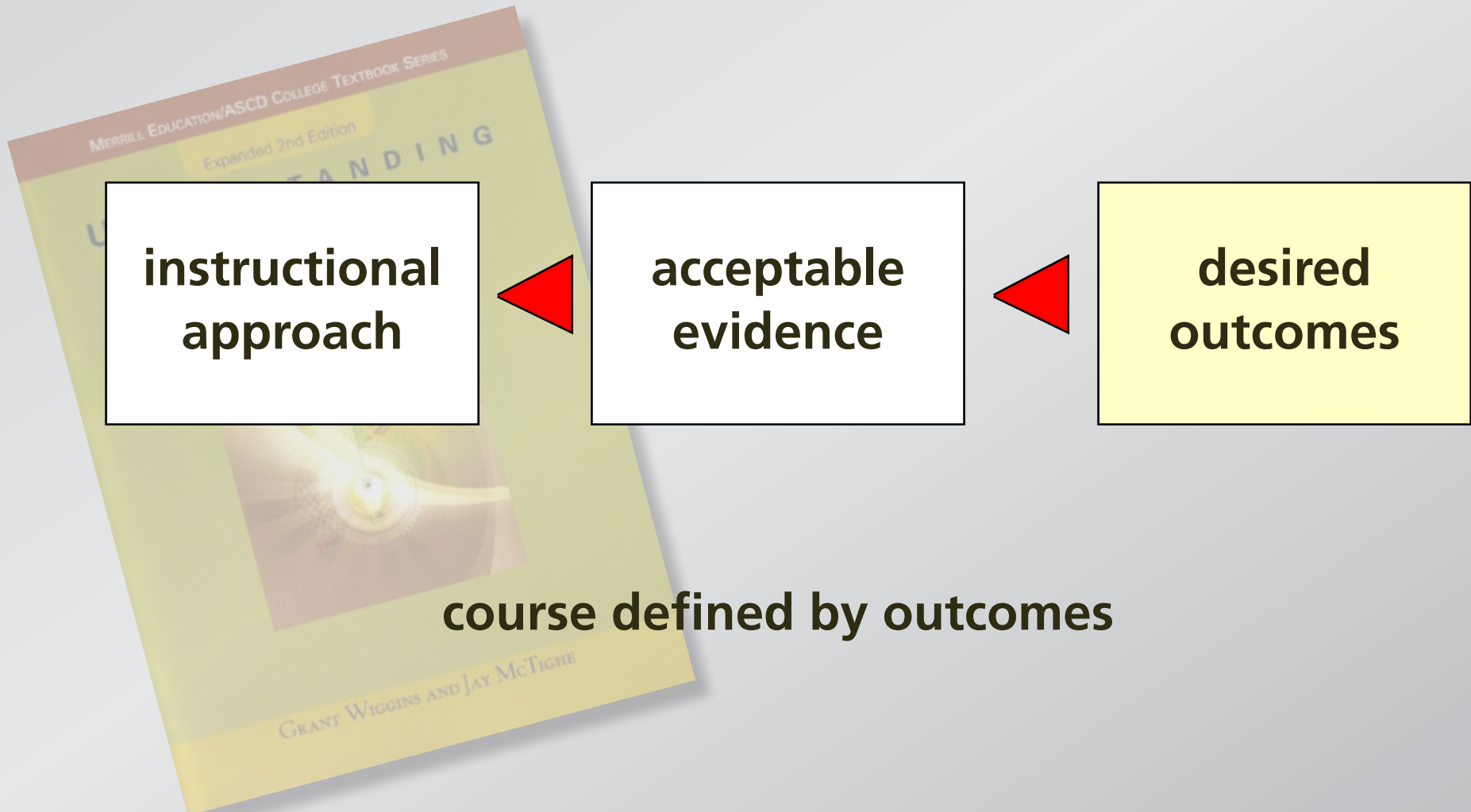
Course design

Backward design



Course design

Backward design



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:

Assignment on the course Web site (as soon as possible)
are 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**

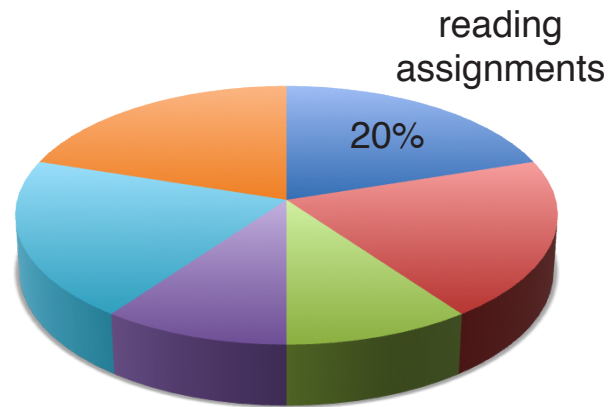
Course design

evaluation



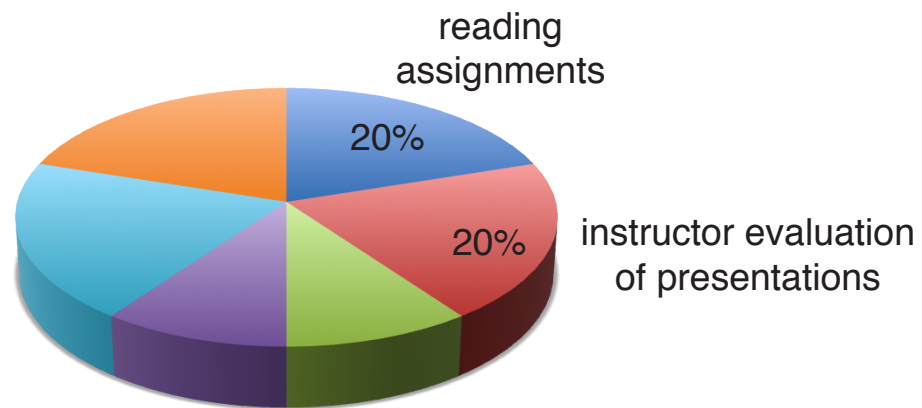
Course design

evaluation



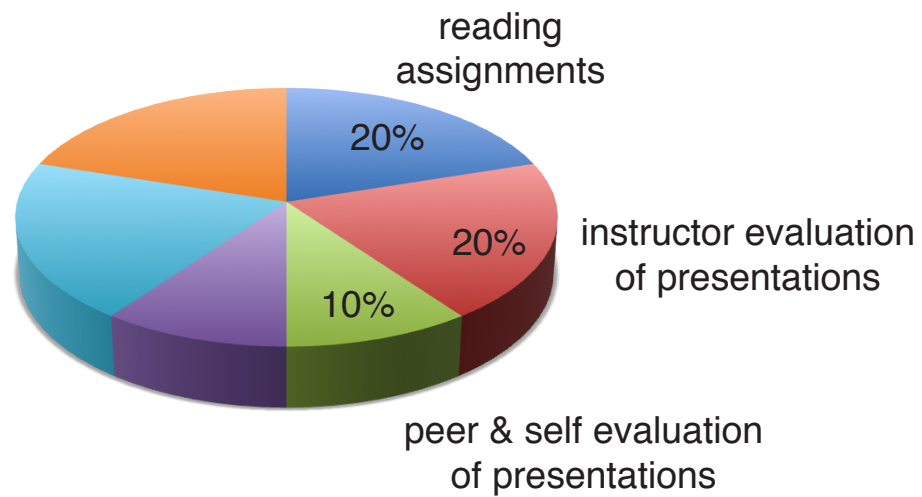
Course design

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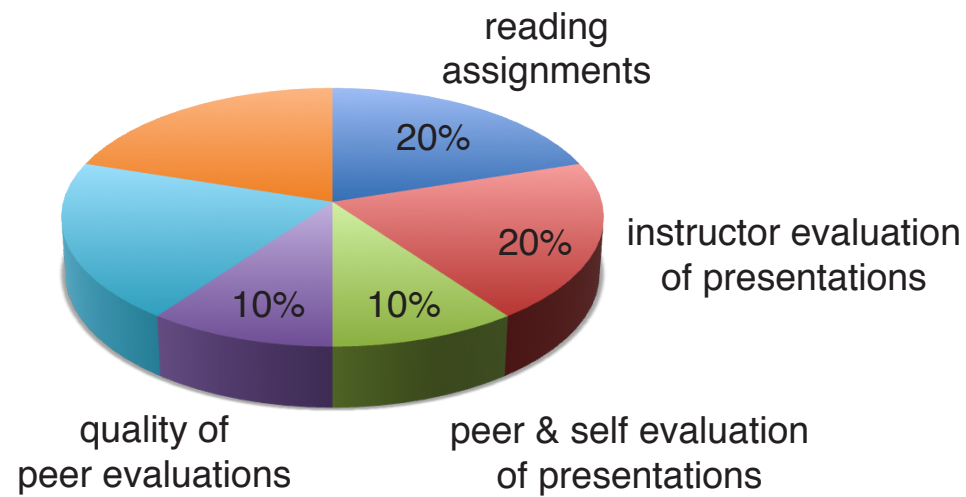
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evaluation



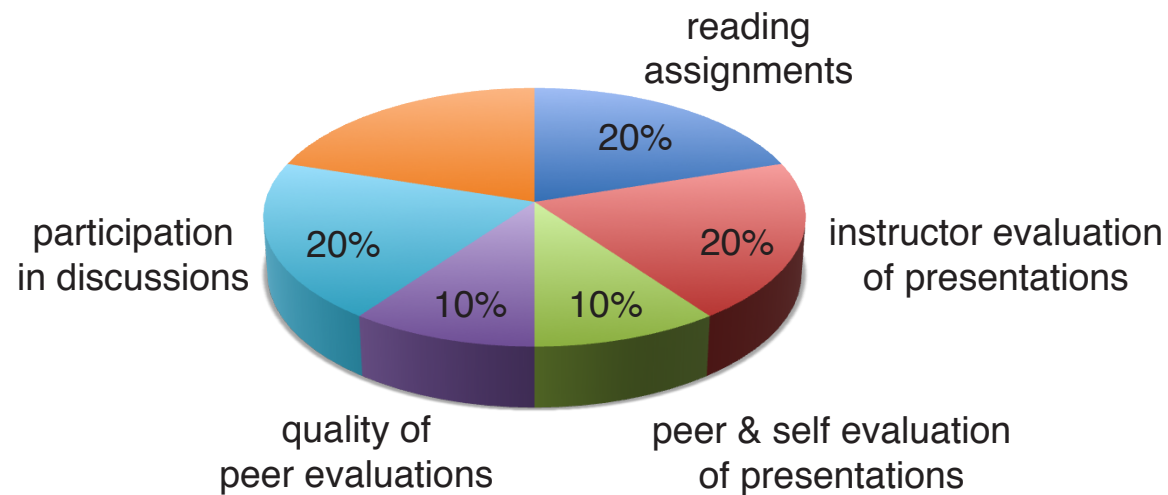
Course design

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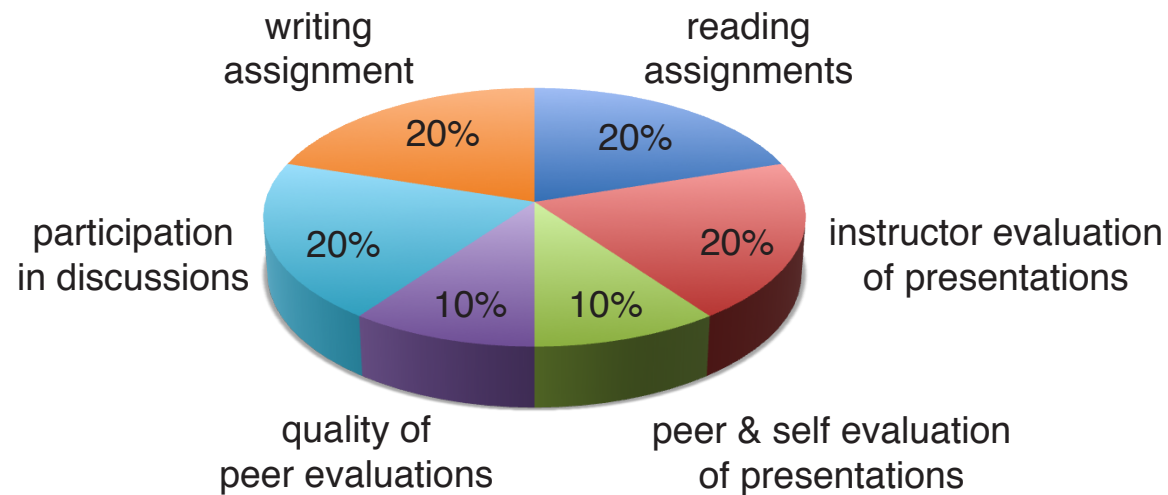
Course design

evaluation



Course design

evaluation



Course design

Rubric-based evaluation

Presenter: _____

Score (1-3)

PRESENTATION RUBRIC

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!)

Nonverbal skills

Posture/poise

Eye contact

Gesticulation/body language and facial expression

Enthusiasm

Volume

Pitch/inflection

Vocabulary

Clarity of speech

Stands up straight, displays little or no tension

Consistent use of direct eye contact with audience

Use of subject

Not used much or used ineffectively

Sometimes reflects lack of interest or negativity toward subject OR not genuine

Sometimes too soft to be heard by all audience members

Pitch was not used to maintain interest or convey emotion OR was used inappropriately

Unexplained terms/jargon used

Occasionally mumbles or can not be understood or mispronounces words

Pauses not intentionally used or

Stands up straight, looks relaxed, confident, and in control

Holds attention of entire audience with

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)

Rubric used for Calibrated Peer Review

Structure

Title

Opening

Paragraph length

Organization

Closing

Scientific facts

Wordy, long, unimaginative, or inappropriate title

Missing a "hook" or a lead in the first paragraphs AND does not orient reader to paragraphs

Many paragraphs are long (6 or more sentences)

Lacks organization; doesn't follow story; paragraph transitions missing

Does not end compellingly or with an

Contains incorrect, misstated, irrelevant, or unnecessary facts

Does not back up facts with proper or convincing sources or evidence

Some originality apparent

Hook or lead present OR first few paragraphs orient reader to subject

Some paragraphs are long (6 or more sentences), most are short (1-5 sentences)

Sticks to story, paragraphs linked

Does not end compellingly or with an

All facts are 100% correct, relevant, and necessary

All facts backed up with proper or convincing sources or evidence

Some originality apparent

Catchy title drawing reader into article

Hook or lead present OR first few paragraphs orient reader to subject

All paragraphs are long (6 or more sentences)

Organization is compelling

Ends compellingly

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

irrelevant question

clarification or comment

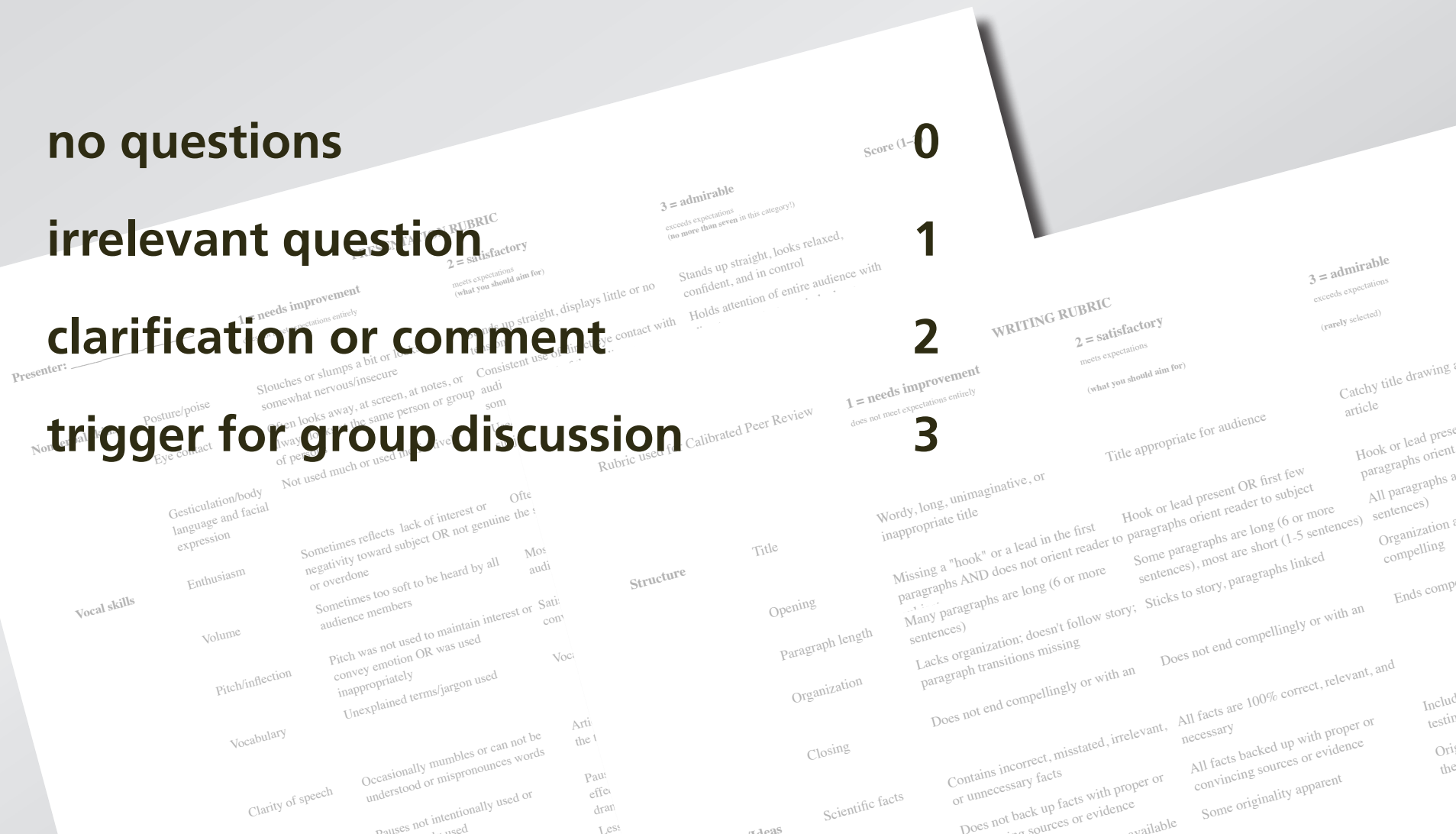
trigger for group discussion

Score 0

1

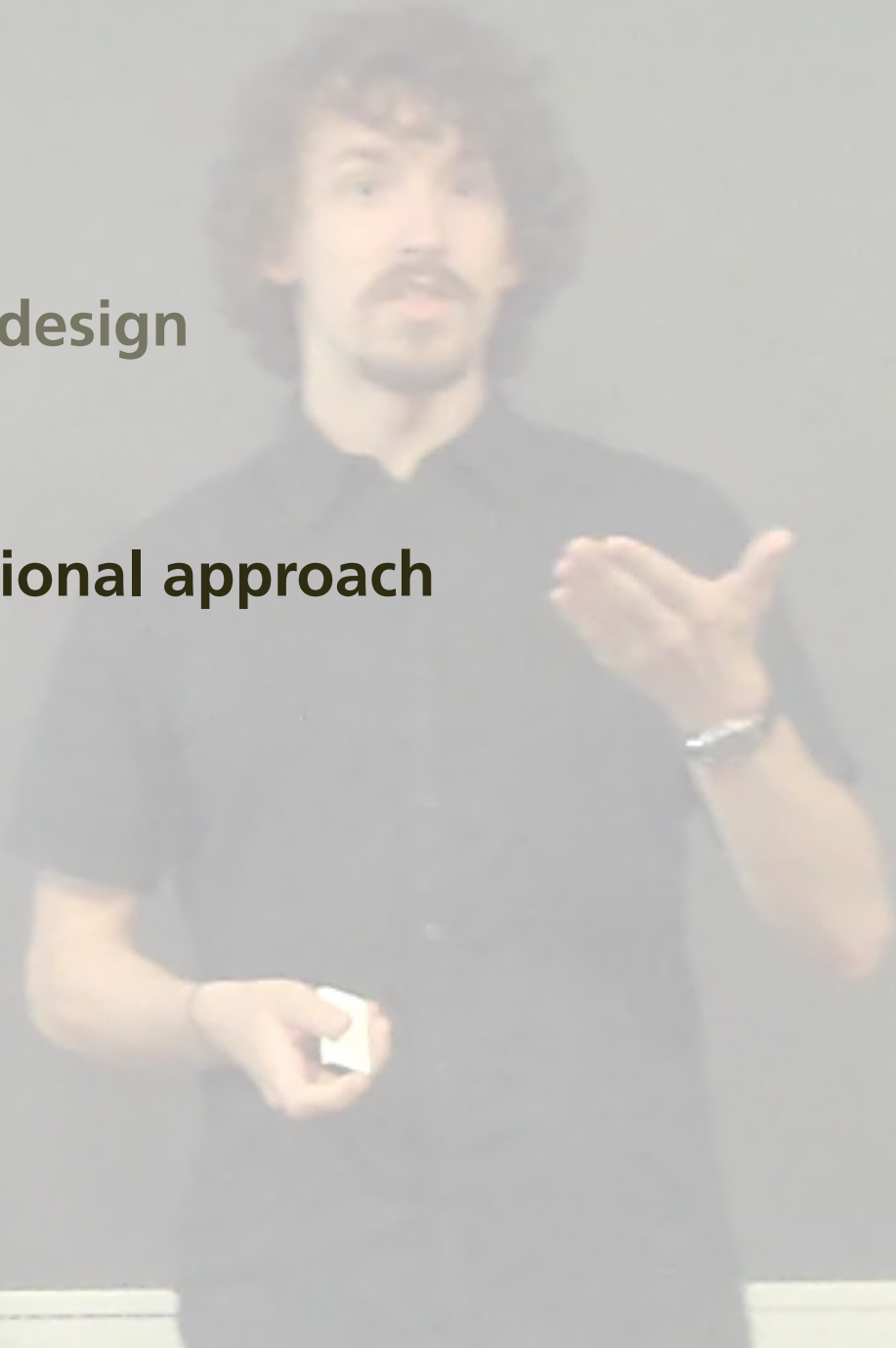
2

3



Outline

- Course design
- Instructional approach
- Results



Instructional approach

semester schedule

Wednesday Night Research Seminars Fall 2009		
DATE	PRESENTER	TITLE
Sep 9	Erel Levine	Information processing by RNA
	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
Sep 30	Bertrand Halperin	Cooled scanning probe microscopy of 2D electrons
	Amir Yacoby	Theory of low-dimensional electron systems
Oct 7	Adam Cohen	Spins and charges at low-dimensionality
	Ronald Walsworth	Quantum coherence in room-temperature liquids
Oct 14	John Doyle	From astrophysics to bio-imaging: new applications of physics tools
	Jerry Gabrielse	The ACME EDM experiment
Oct 21	Douglas Finkbeiner	Studies of fundamental symmetries in low-energy experiments
	Christopher Stubbs	Astroparticle physics: the hunt for dark matter
Oct 28	David Weitz	Dark energy, a crisis for fundamental physics
	Eugene Demler	Soft condensed matter and microfluidics
Nov 4	Howard Georgi	Condensed matter theory
	Matthew Schwartz	Unparticle physics
Nov 18	João Guimaraes da Costa	Theoretical particle physics at the hunt for the next standard model
	John Huth	Physics at the Large Hadron Collider
		Physics at the Large Hadron Collider
		Quantum simulations
		Low-Dimensional Electronics and Quantum Information

Instructional approach

semester schedule

intro lecture on
presentation skills

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intro lecture on presentation skills

team presentations

Instructional approach

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intro lecture on presentation skills

team presentations

individual presentations

Instructional approach

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intro lecture on
presentation skills

team
presentations

individual
presentations

individual
presentations
(3 slides)

Instructional approach

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intro lecture on presentation skills

team presentations

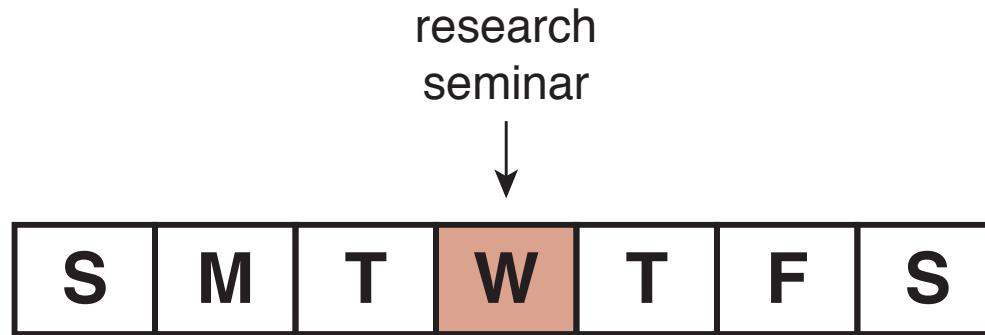
individual presentations

individual presentations (3 slides)

writing assignment

Instructional approach

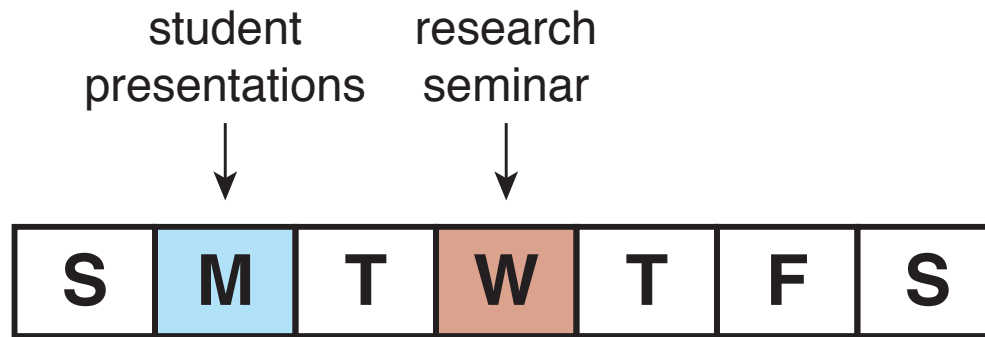
weekly schedule



 all

Instructional approach

weekly schedule

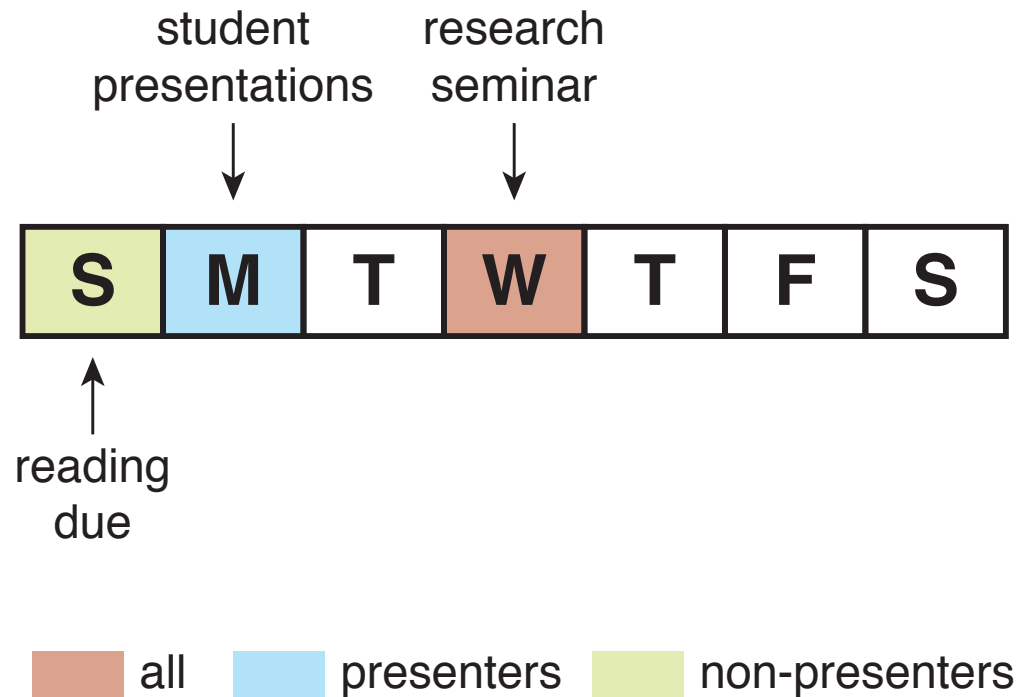


all

presenters

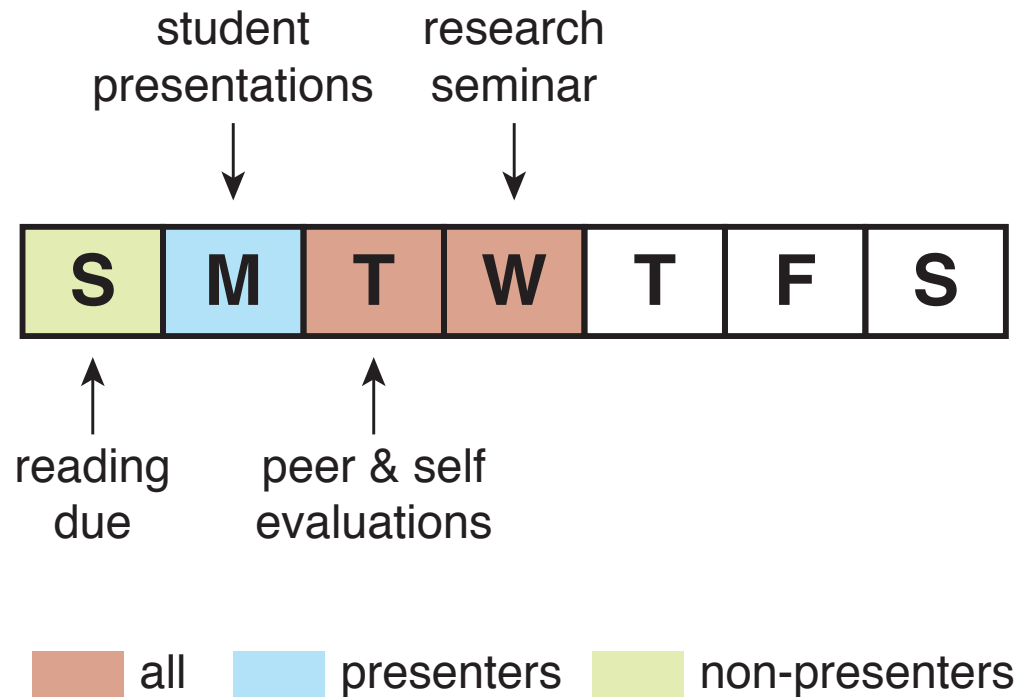
Instructional approach

weekly schedule



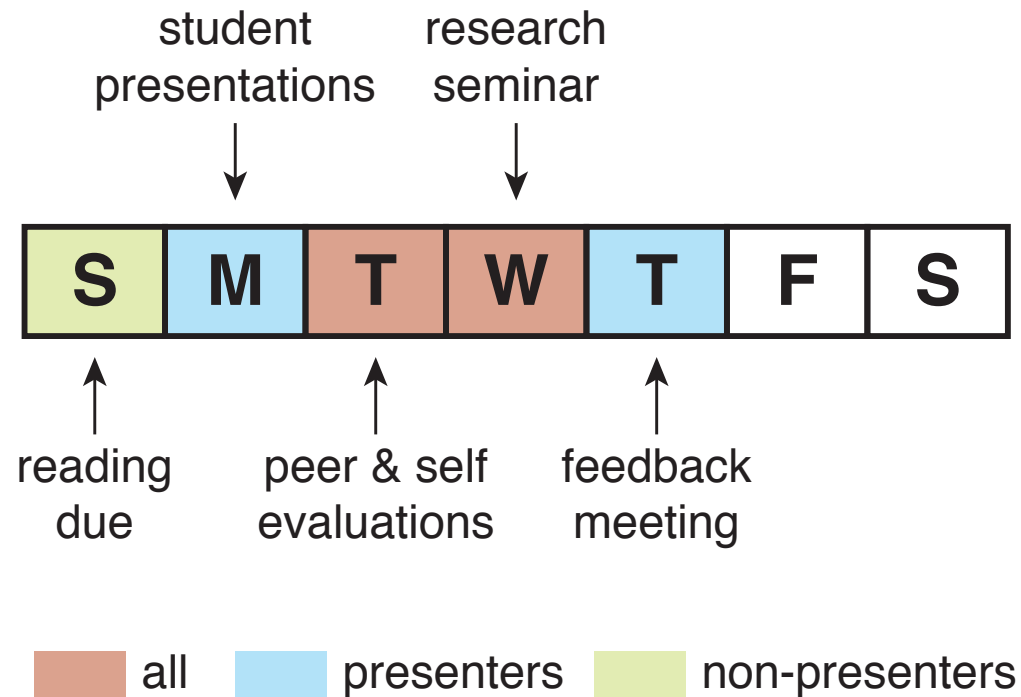
Instructional approach

weekly schedule



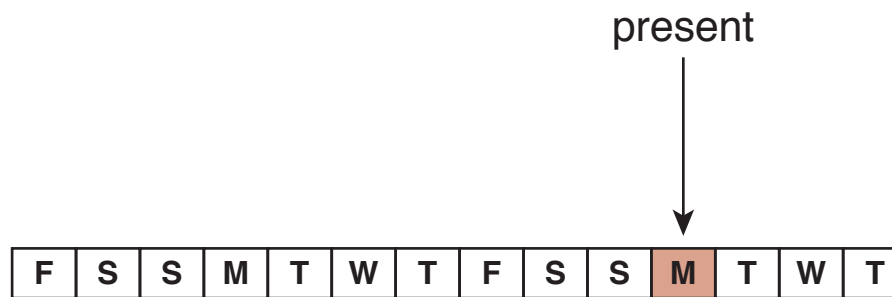
Instructional approach

weekly schedule



Instructional approach

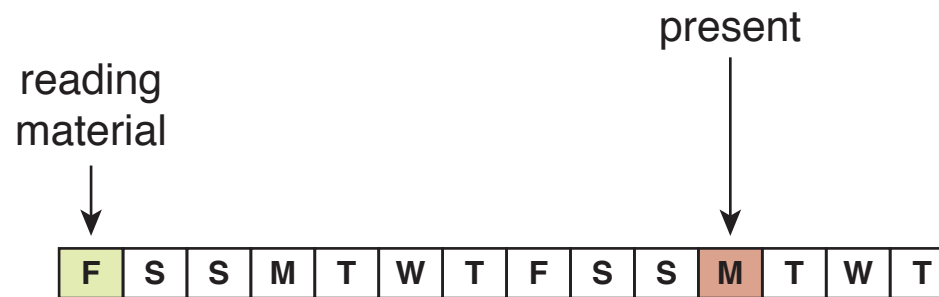
presentation workflow



 face-to-face

Instructional approach

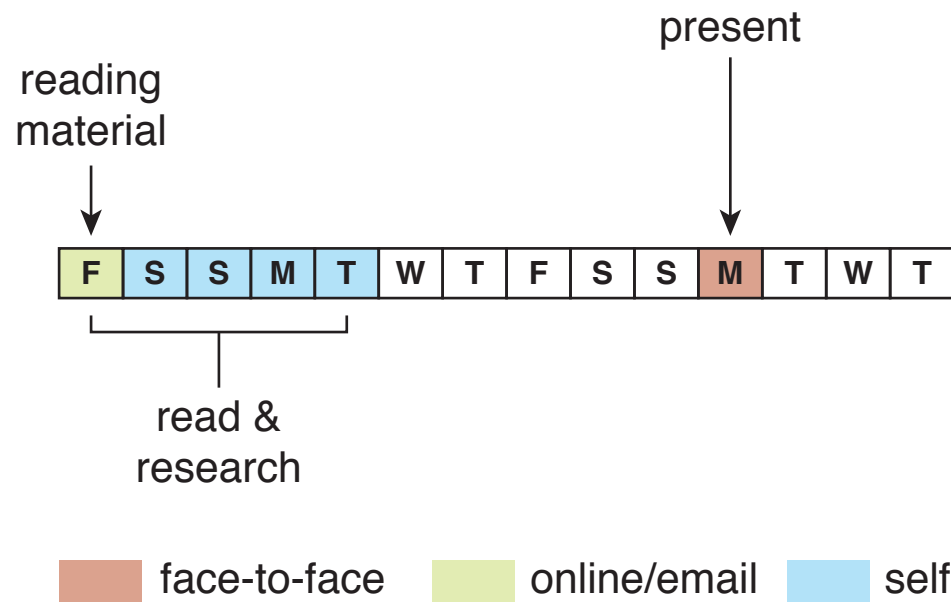
presentation workflow



face-to-face online/email

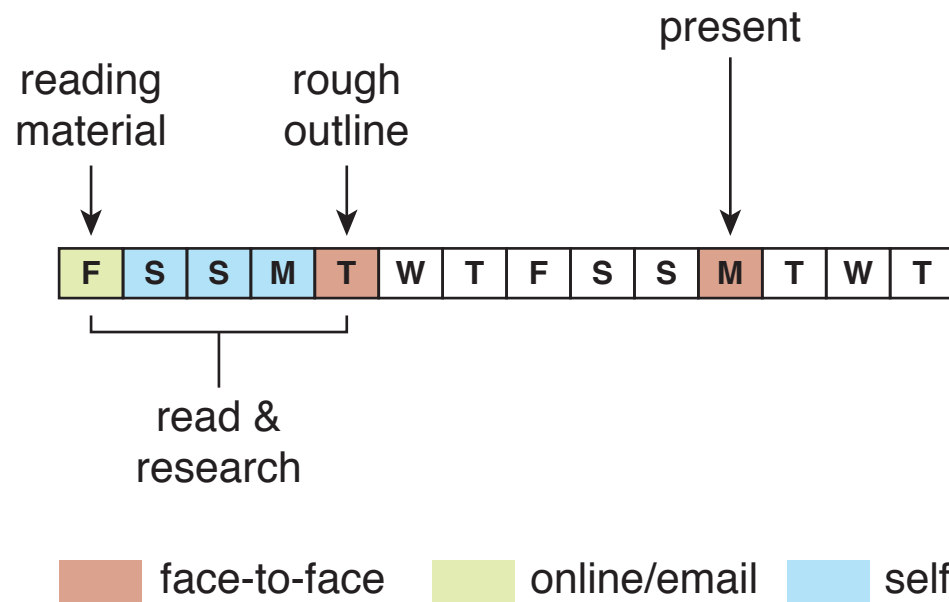
Instructional approach

presentation workflow



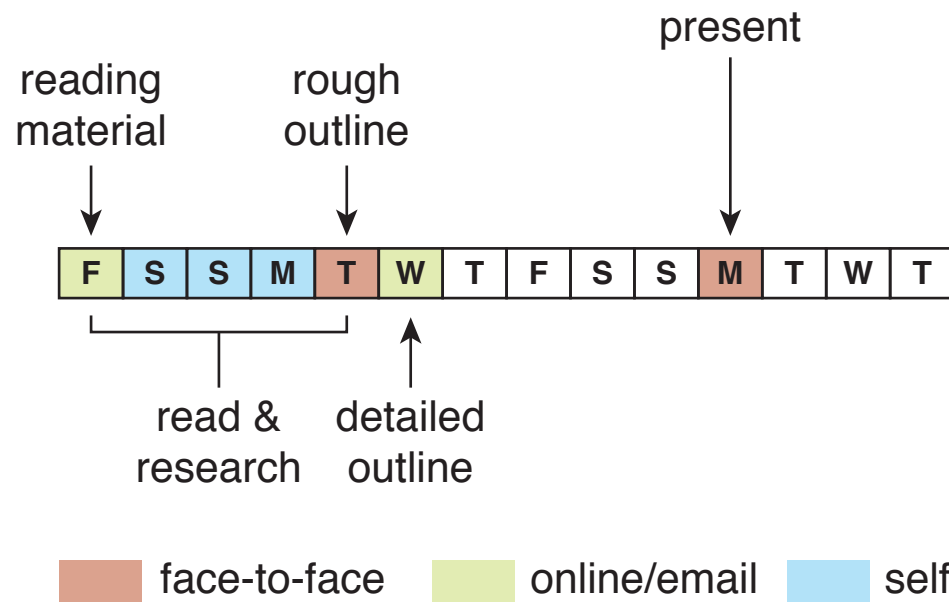
Instructional approach

presentation workflow



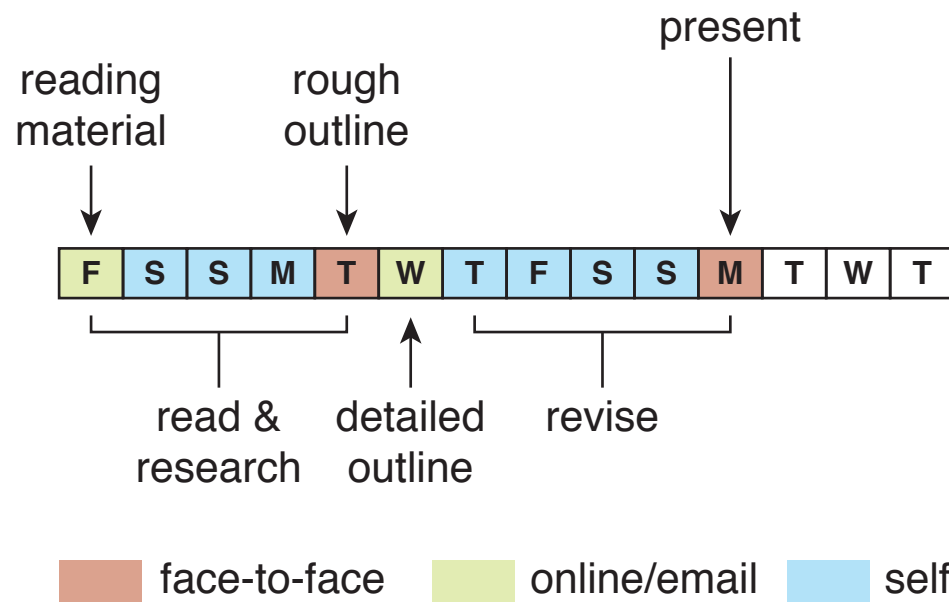
Instructional approach

presentation workflow



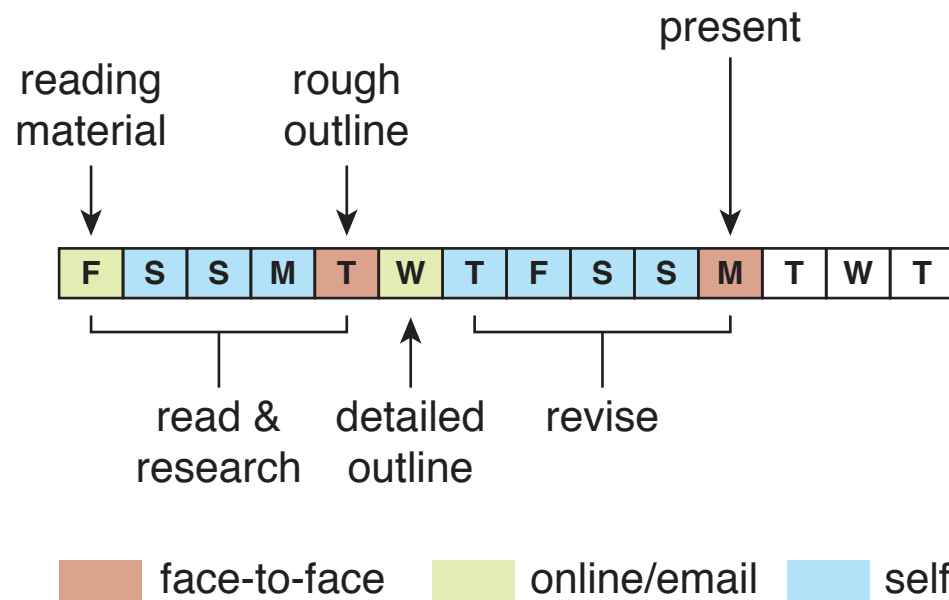
Instructional approach

presentation workflow



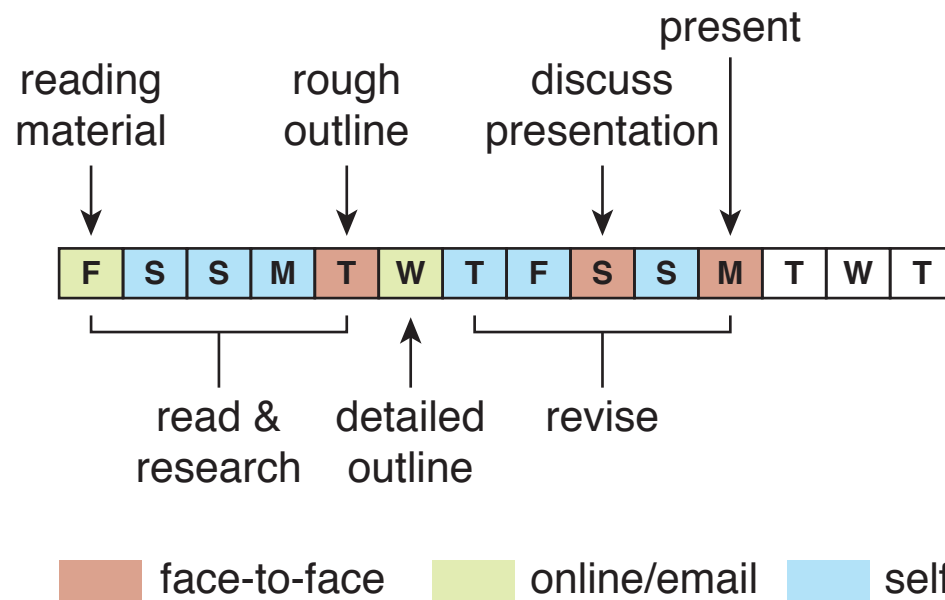
Instructional approach

presentation workflow



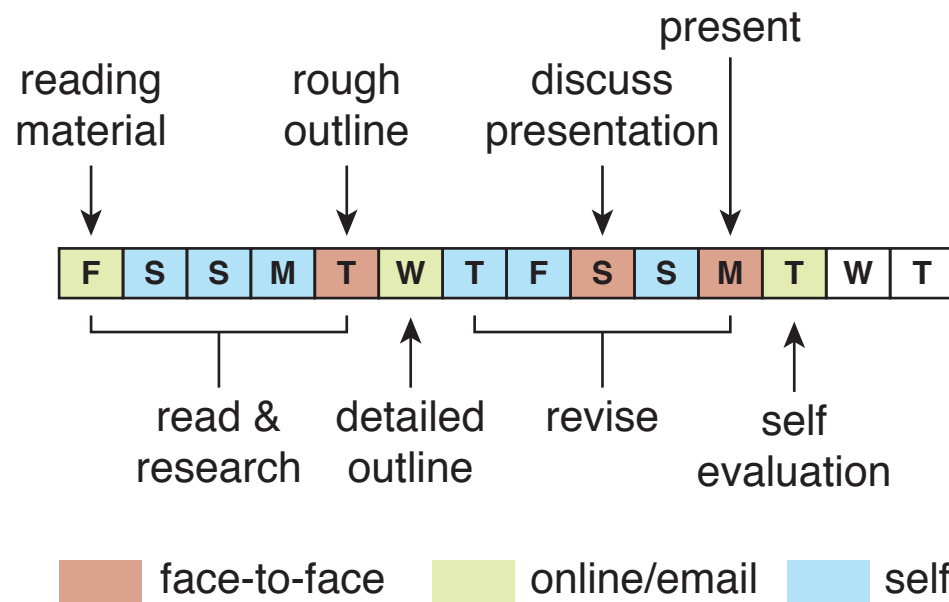
Instructional approach

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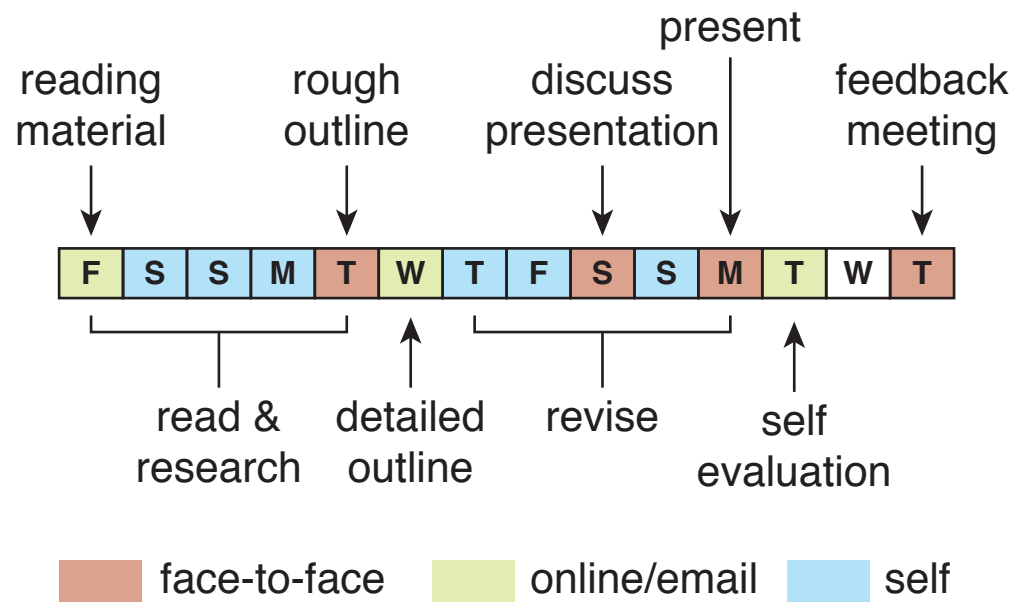
Instructional approach

presentation workflow



Instructional approach

presentation workflow



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**
- **medium: newspaper article (scenario-driven)**

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

Instructional approach

instructor activities

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

Instructional approach

instructor activities

	traditional	seminar
preparation	lecture	reading material
class	deliver lecture	
1-on-1 meetings	optional	
out of class grading	term papers	

Instructional approach

instructor activities

	traditional	seminar
preparation	lecture	reading material
class	deliver lecture	attend
1-on-1 meetings	optional	
out of class grading	term papers	

Instructional approach

instructor activities

	traditional	seminar
preparation	lecture	reading material
class	deliver lecture	attend
1-on-1 meetings	optional	7–10 per student
out of class grading	term papers	

Instructional approach

instructor activities

	traditional	seminar
preparation	lecture	reading material
class	deliver lecture	attend
1-on-1 meetings	optional	7–10 per student
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Instructional approach

instructor activities

	traditional	seminar
preparation	lecture	reading material
class	deliver lecture	attend
1-on-1 meetings	optional	7–10 per student
out of class grading	term papers	none

Instructional approach

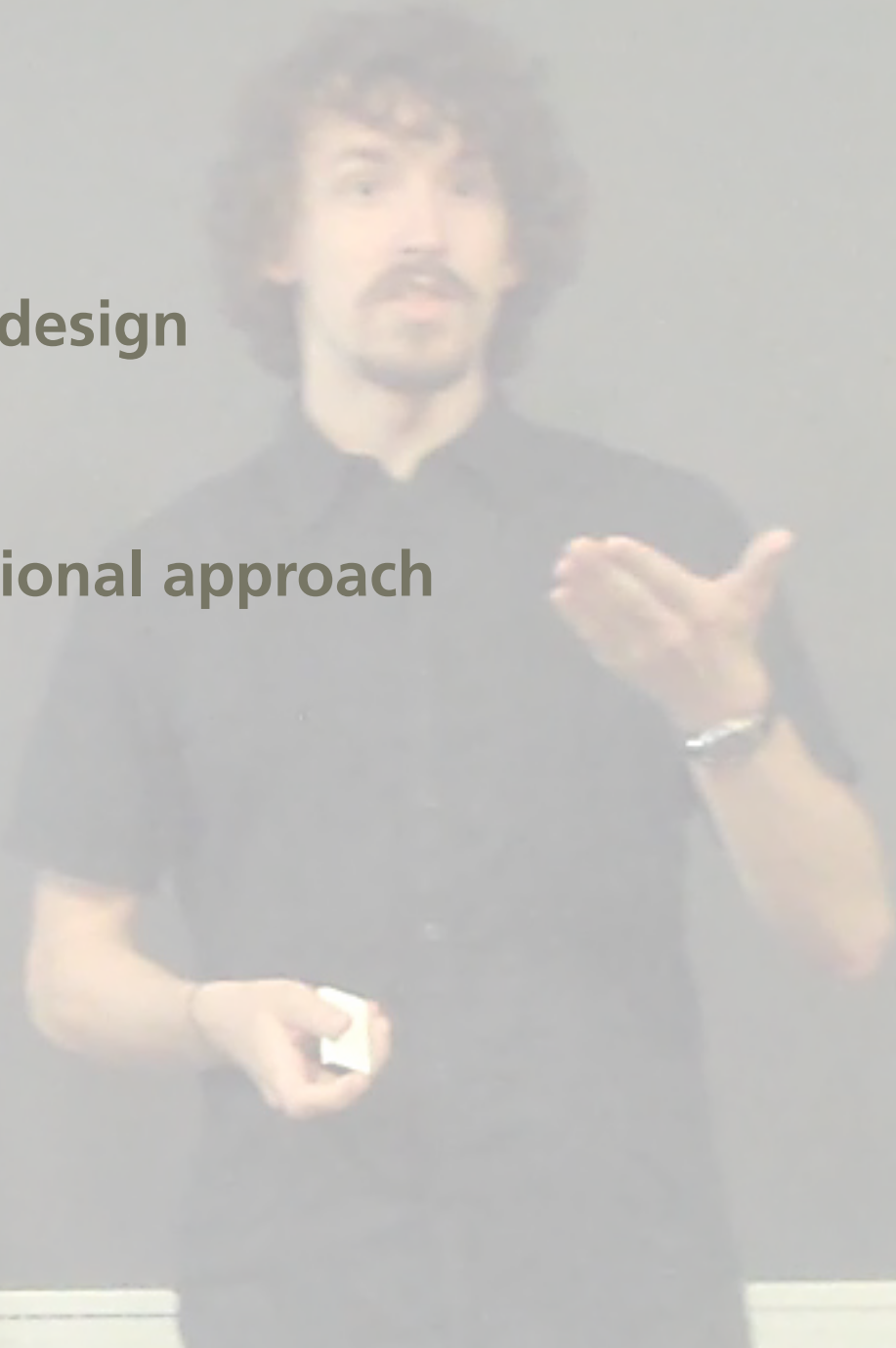
instructor activities

	traditional	seminar
preparation	lecture	reading material
class	deliver lecture	attend
1-on-1 meetings	optional	7–10 per student
out of class grading	term papers	none

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

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).”

“Really important and rare opportunity to develop essential skills that you don’t learn in other physics classes.”

Results

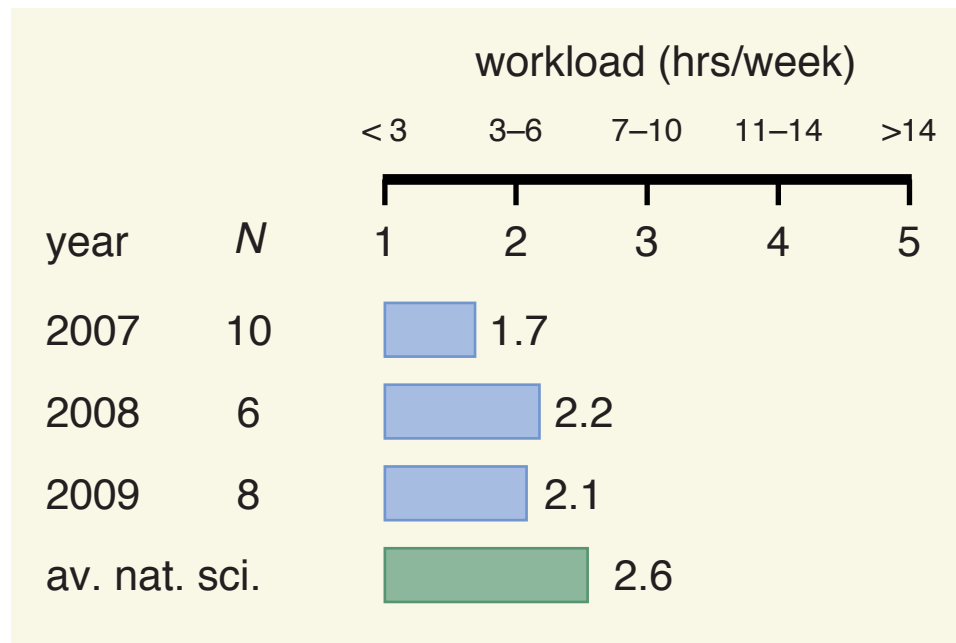
Learning happens:

“Wonderful class — you’ll learn more in this class than many of the other physics classes at Harvard.”

“One of the few courses I’ve taken where the amount learned doesn’t match the difficulty of the work.”

Results

workload



Results

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."

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

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

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**

Results

After course, will be able to

- **draw on broad knowledge base in current physics ✓**
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- **write scientific article for non-science audience ✓**
- **evaluate your own and others' work ✓**

Conclusions

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

Funding:

National Science Foundation

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