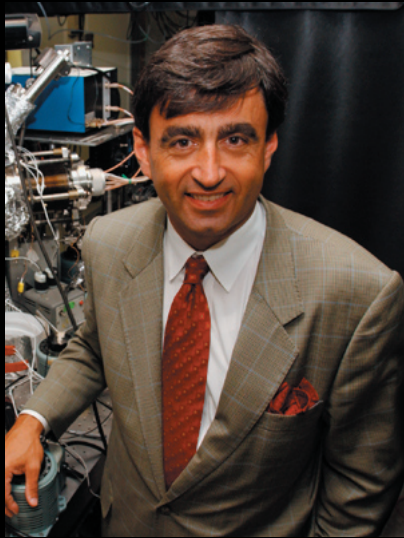


Using technology to facilitate learning in large lecture classes

University of Colorado
Boulder, CO, 22 April 2004





Eric Mazur



Veronica McCauley



Suvendra Dutta

and also...

Programming:

**Michael Tucker
Jean Moreau
Olaf Jonmarker
Vijay Salagala
Juston Payne**

Editing:

**Prof. Ed. Ginsberg (UMass Boston)
Prof. Peter Dourmashkin (MIT)
Prof. Chris Gould (USC)**

Beta testing:

**Prof. John Belcher (MIT)
Andrew McKinney (MIT)
Sue Gautsch (USC)
Prof. Catherine Crouch (Swarthmore)
Prof. Clifford V. Johnson (USC)**

...and hundreds students in dozens of courses

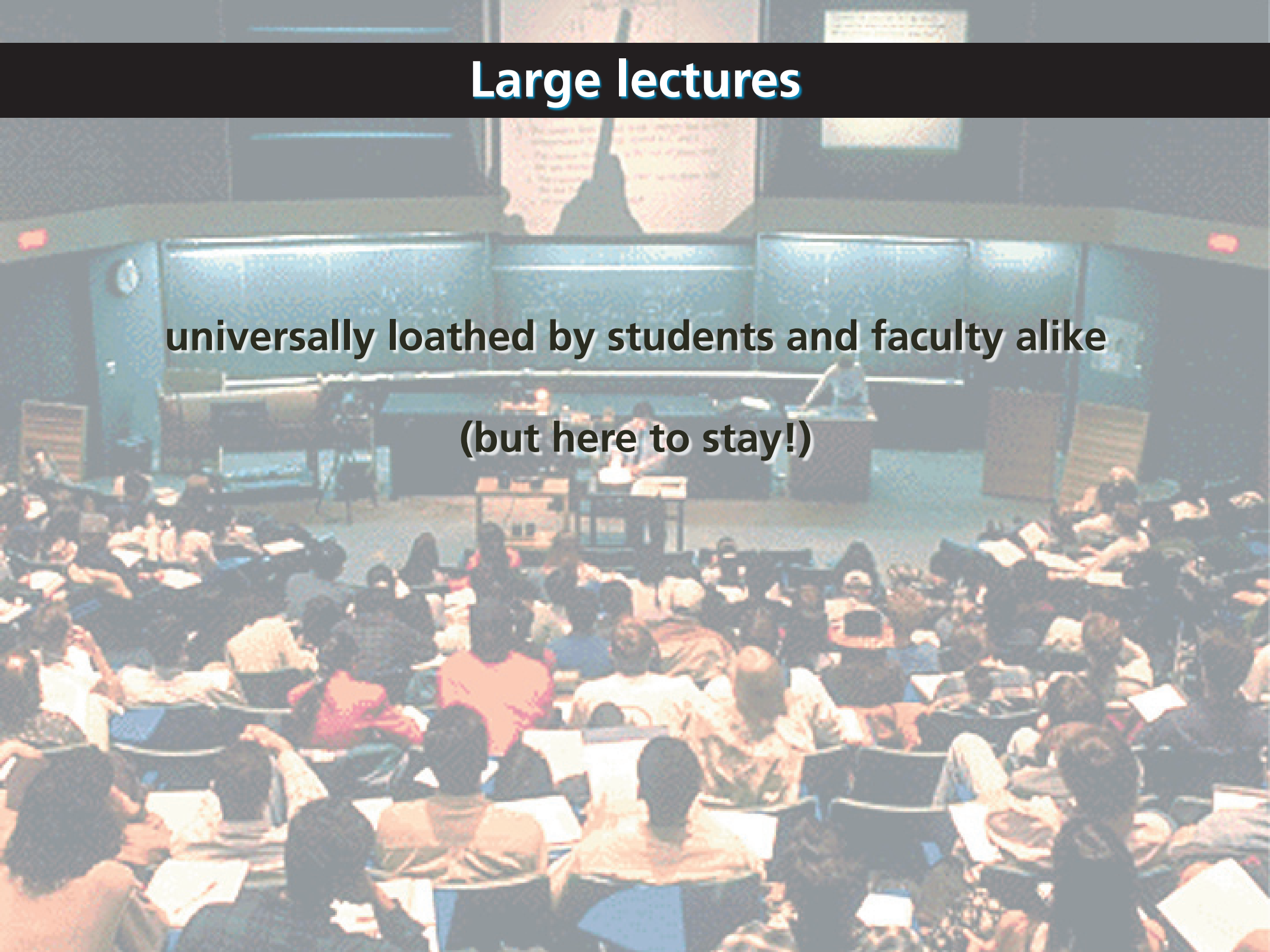
Large lectures



Large lectures

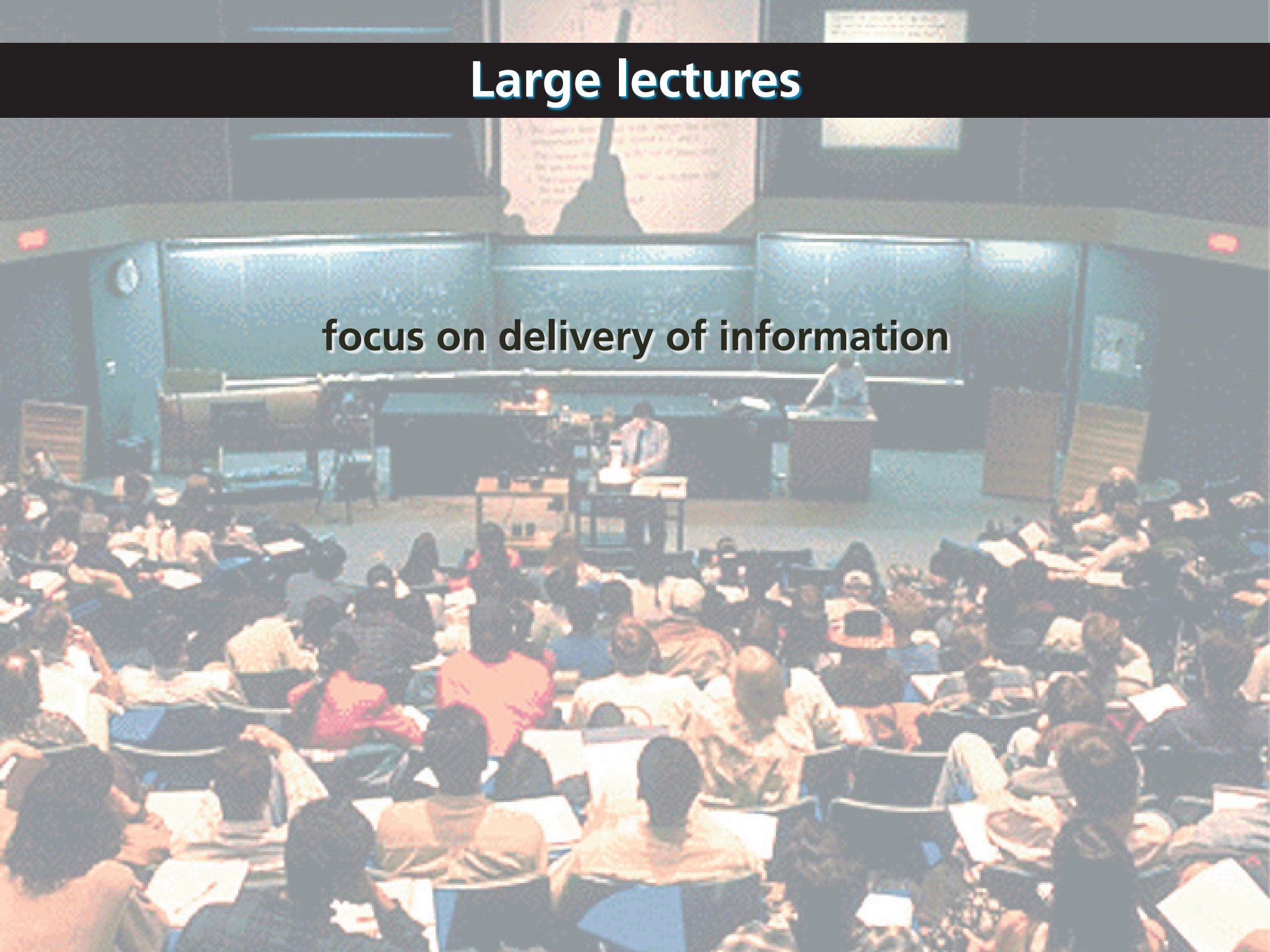
universally loathed by students and faculty alike

(but here to stay!)



Large lectures

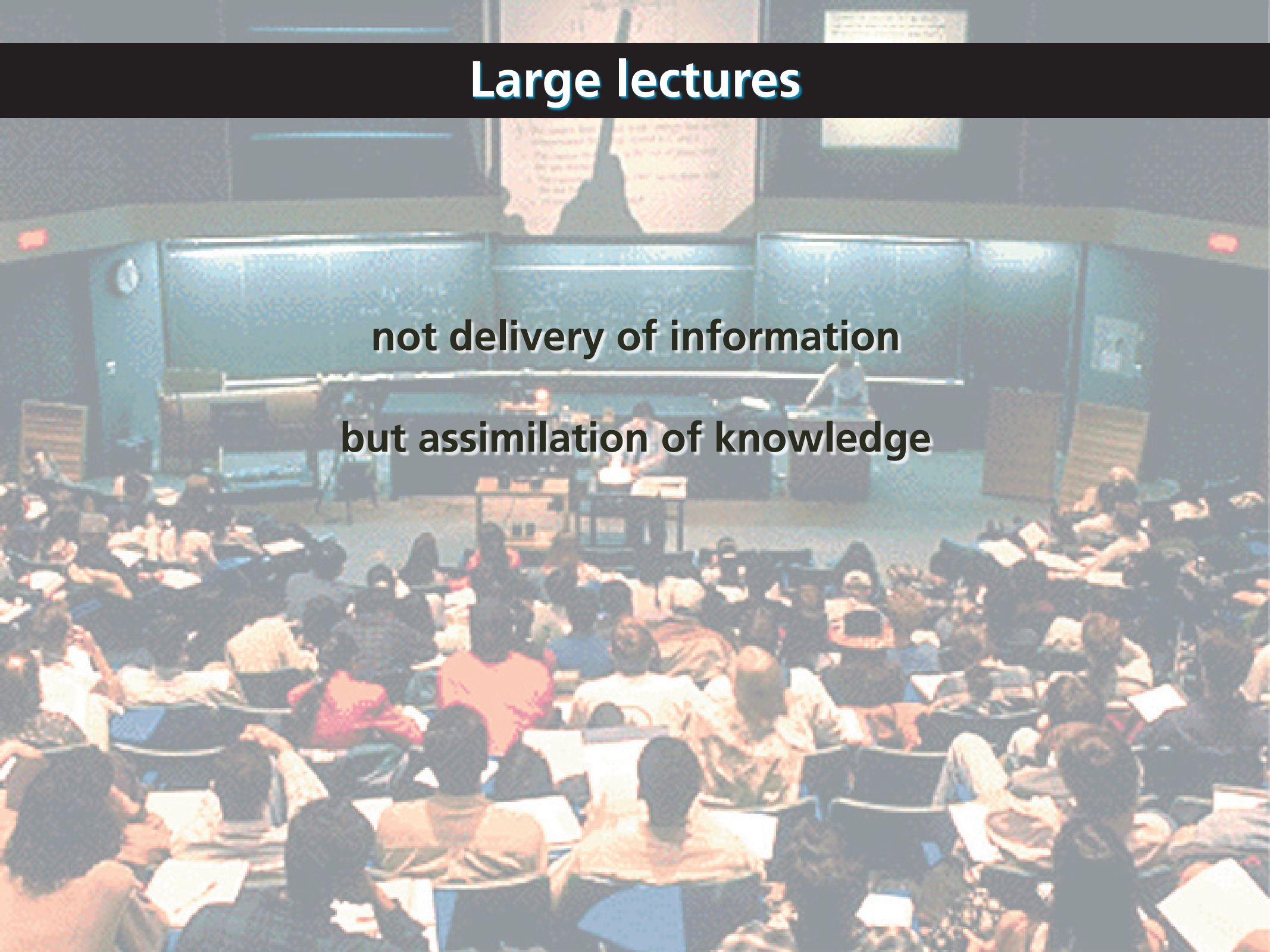
focus on delivery of information



Large lectures

not delivery of information

but assimilation of knowledge



Large lectures

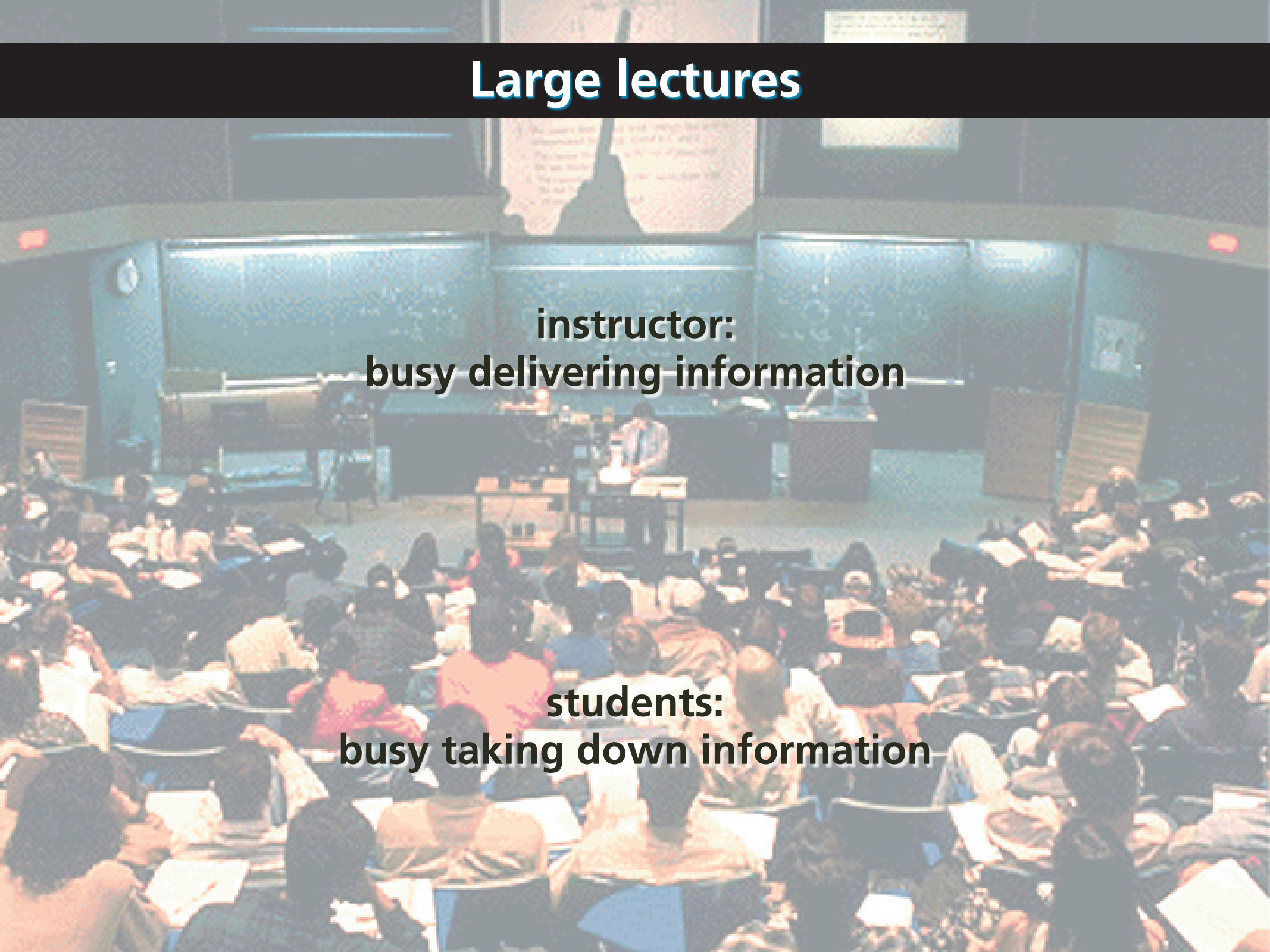
**instructor:
busy delivering information**

A wide-angle photograph of a large lecture hall. An instructor is standing at a podium at the front of the room, facing a large audience of students seated at desks. The room has a curved wall with several large windows or screens. The lighting is somewhat dim, and the overall atmosphere is that of a formal academic setting.

Large lectures

**instructor:
busy delivering information**

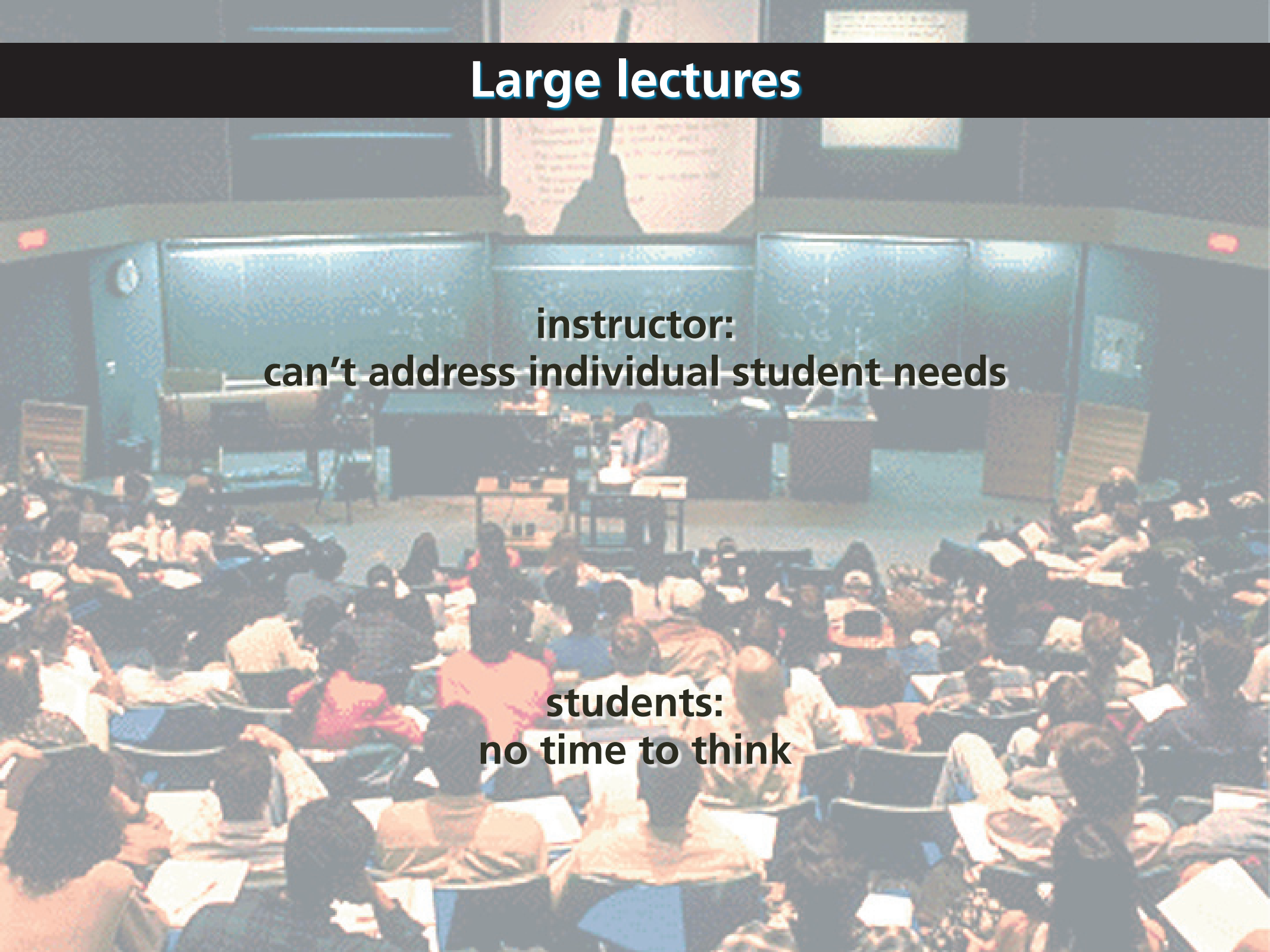
**students:
busy taking down information**



Large lectures

**instructor:
can't address individual student needs**

**students:
no time to think**



Technology



Technology

not a magic bullet

Technology

new method for delivering old content

Interactive Learning Toolkit

Use technology to

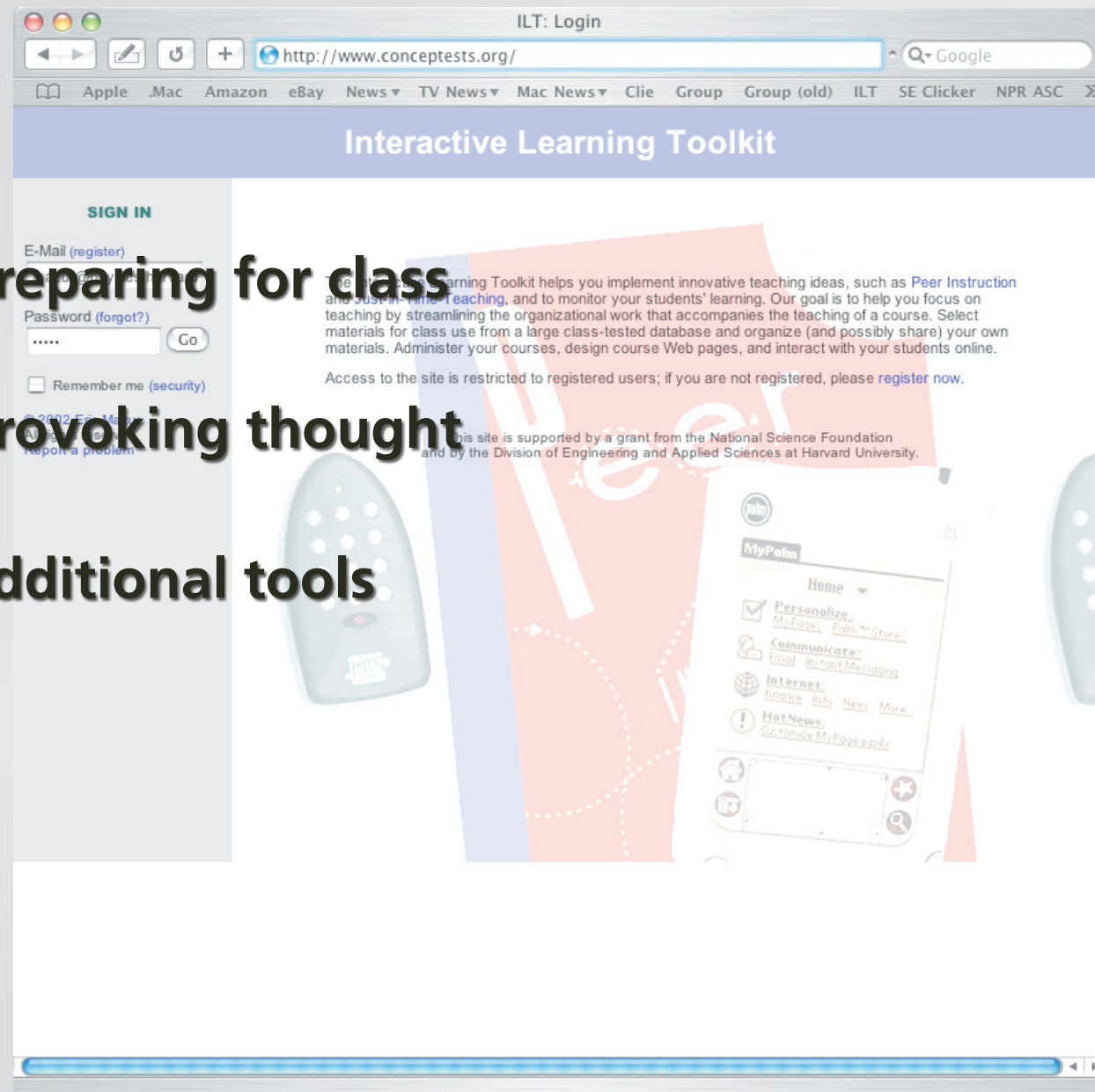
- **facilitate new modes of learning**
- **increase interaction**
- **help instructor address student needs**

Interactive Learning Toolkit

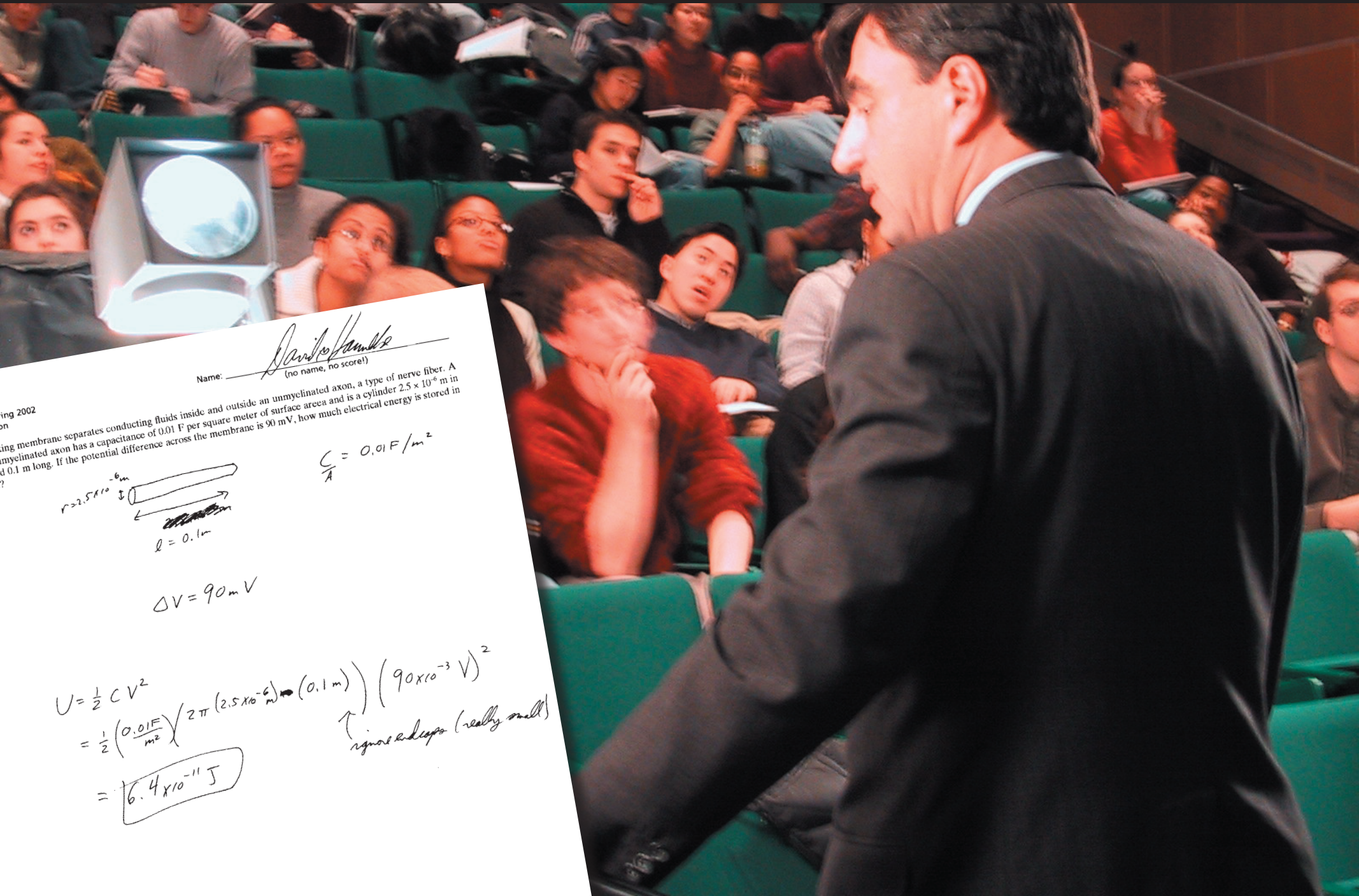
The screenshot shows a web browser window titled "ILT: Login" with the URL "http://www.concepttests.org/". The browser's address bar and search bar are visible. Below the browser window, the website's header features the title "Interactive Learning Toolkit" in a blue banner. On the left side, there is a "SIGN IN" section with a form for "E-Mail (register)" containing the address "mazur@physics.harvard" and a "Password (forgot?)" field with a "Go" button. A "Remember me (security)" checkbox is also present. Below the sign-in form, the copyright notice reads "© 2002 Eric Mazur All rights reserved Report a problem". The main content area contains a large graphic with a red and blue background, featuring a stylized "e" and a "palm" logo. Text on the page describes the toolkit's purpose: "The Interactive Learning Toolkit helps you implement innovative teaching ideas, such as Peer Instruction and Just-in-Time-Teaching, and to monitor your students' learning. Our goal is to help you focus on teaching by streamlining the organizational work that accompanies the teaching of a course. Select materials for class use from a large class-tested database and organize (and possibly share) your own materials. Administer your courses, design course Web pages, and interact with your students online." It also states that access is restricted to registered users and provides a link to "register now". At the bottom, it mentions support from the National Science Foundation and the Division of Engineering and Applied Sciences at Harvard University. The graphic also includes images of a Palm OS handheld device and a remote control.

Outline

- preparing for class
- provoking thought
- additional tools

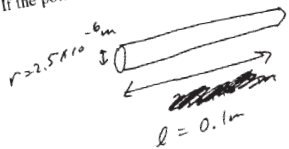


Preparing for class



Name: David VanDyke
(no name, no score!)

ing 2002
on
ing membrane separates conducting fluids inside and outside an unmyelinated axon, a type of nerve fiber. A
myelinated axon has a capacitance of 0.01 F per square meter of surface area and is a cylinder 2.5×10^{-6} m in
d 0.1 m long. If the potential difference across the membrane is 90 mV, how much electrical energy is stored in
?



$$\frac{C}{A} = 0.01 \text{ F/m}^2$$

$$\Delta V = 90 \text{ mV}$$

$$U = \frac{1}{2} C V^2$$
$$= \frac{1}{2} \left(\frac{0.01 \text{ F}}{\text{m}^2} \right) \left(2\pi (2.5 \times 10^{-6} \text{ m}) (0.1 \text{ m}) \right) (90 \times 10^{-3} \text{ V})^2$$

↑ ignore end caps (really small)

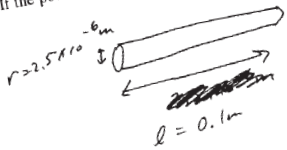
$$= \boxed{6.4 \times 10^{-11} \text{ J}}$$

Preparing for class

nameless faces

Name: David Hamble
(no name, no score!)

ing 2002
on
ing membrane separates conducting fluids inside and outside an unmyelinated axon, a type of nerve fiber. A
myelinated axon has a capacitance of 0.01 F per square meter of surface area and is a cylinder 2.5×10^{-6} m in
d 0.1 m long. If the potential difference across the membrane is 90 mV, how much electrical energy is stored in
?



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$$= \frac{1}{2} \left(\frac{0.01 \text{ F}}{\text{m}^2} \right) \left(2\pi (2.5 \times 10^{-6} \text{ m}) (0.1 \text{ m}) \right) (90 \times 10^{-3} \text{ V})^2$$

↑ ignore end caps (really small)

$$= \boxed{6.4 \times 10^{-11} \text{ J}}$$

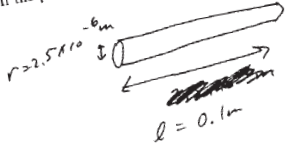
Preparing for class

nameless faces

Name: Daniel Vandenberg
(no name, no score!)

ing 2002
on
ing membrane separates conducting fluids inside and outside an unmyelinated axon, a type of nerve fiber. A
unmyelinated axon has a capacitance of 1 pF per square meter of surface area and is a cylinder $2.5 \times 10^{-6} \text{ m}$ in
d 0.1 m long. If the potential difference across the membrane is 90 mV , how much electrical energy is stored in
?

faceless names



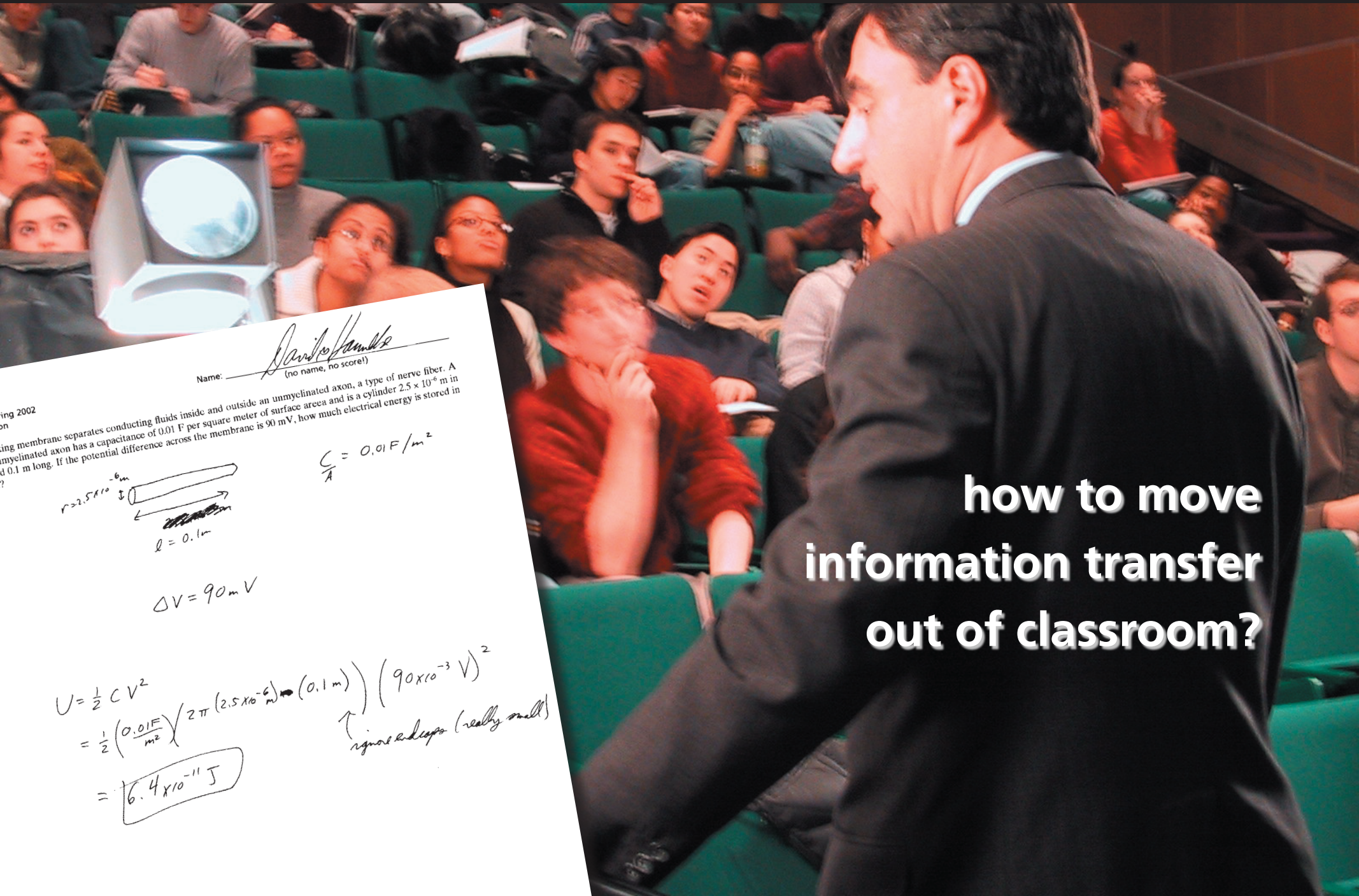
$$\Delta V = 90 \text{ mV}$$

$$U = \frac{1}{2} C V^2$$
$$= \frac{1}{2} \left(\frac{0.01 \text{ F}}{\text{m}^2} \right) \left(2\pi (2.5 \times 10^{-6} \text{ m}) (0.1 \text{ m}) \right) (90 \times 10^{-3} \text{ V})^2$$

↑ ignore end caps (really small)

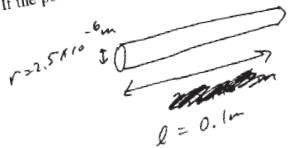
$$= \boxed{6.4 \times 10^{-11} \text{ J}}$$

Preparing for class



Name: Daniel Vandenberg
(no name, no score!)

ing 2002
on
ing membrane separates conducting fluids inside and outside an unmyelinated axon, a type of nerve fiber. A
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d 0.1 m long. If the potential difference across the membrane is 90 mV, how much electrical energy is stored in
?



$$\frac{C}{A} = 0.01 \text{ F/m}^2$$

$$\Delta V = 90 \text{ mV}$$

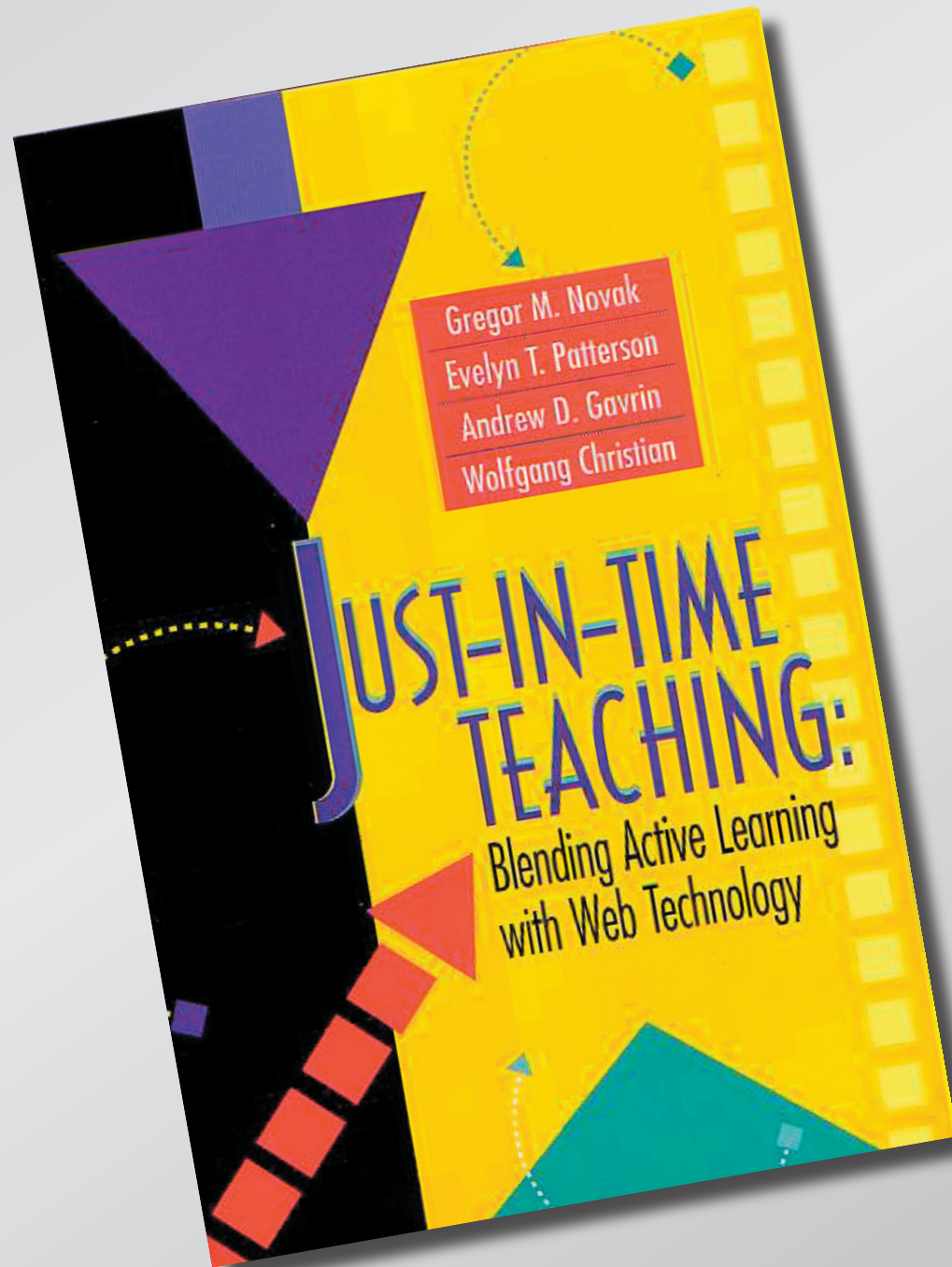
$$U = \frac{1}{2} C V^2$$
$$= \frac{1}{2} \left(\frac{0.01 \text{ F}}{\text{m}^2} \right) \left(2\pi (2.5 \times 10^{-6} \text{ m}) (0.1 \text{ m}) \right) (90 \times 10^{-3} \text{ V})^2$$

↑ ignore end caps (really small)

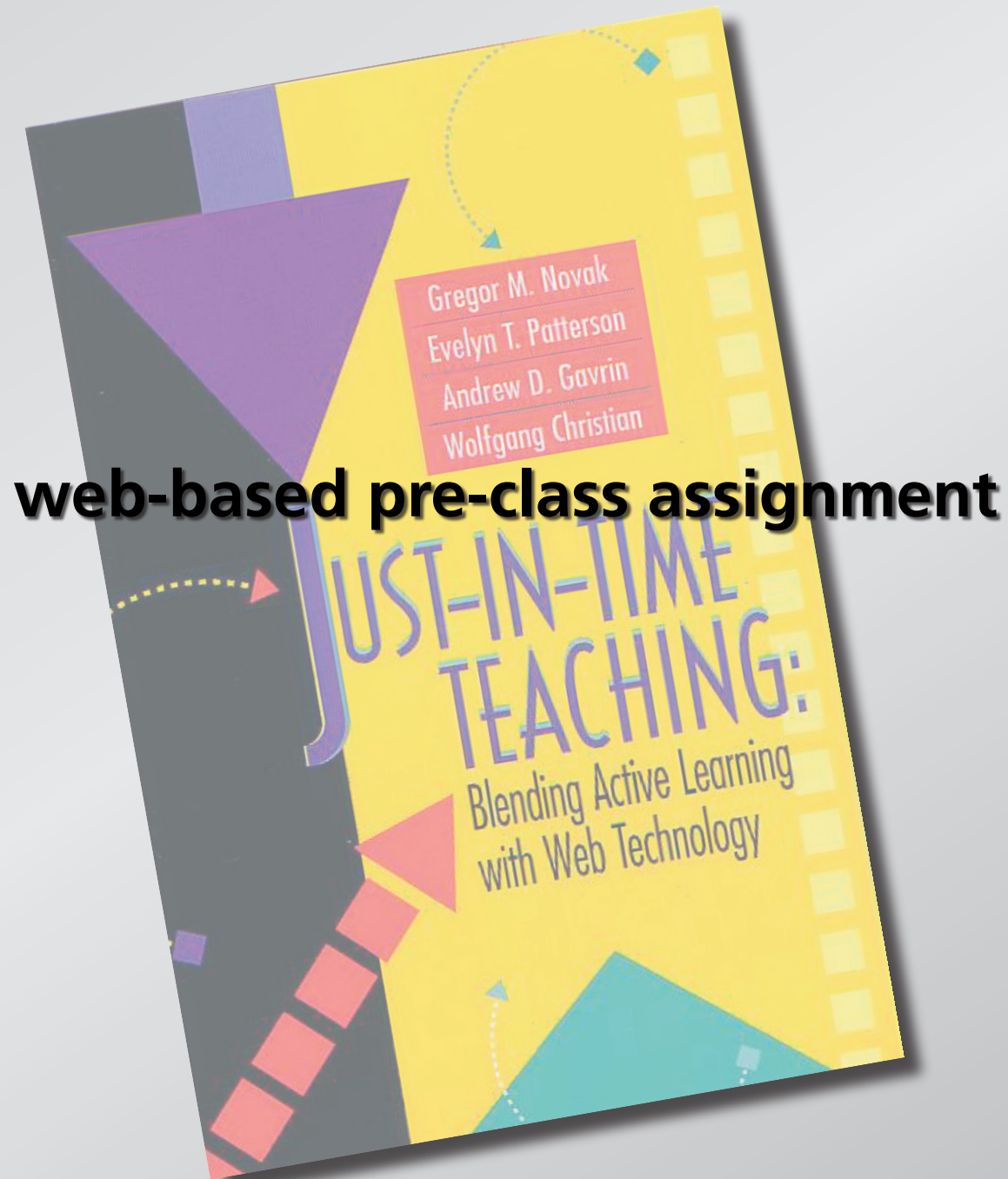
$$= \boxed{6.4 \times 10^{-11} \text{ J}}$$

how to move
information transfer
out of classroom?

Preparing for class



Preparing for class



Preparing for class

ILT: Students

http://www.conceptest.org/

ILT DEAS Apple Visualization HPC Education Local Info IBM Culture General Computer Mazur

Physics 1b Logged in as Eric Mazur
Sign out

HOME READING LECTURES ASSIGNMENTS FORUMS NEWS HANDOUTS ?

Courses > Physics 1b > Reading > Changing magnetic fields II > < Student Responses

Please tell us briefly what **single** point of the reading you found most difficult or confusing. If you did not find any part of it difficult or confusing, please tell us what parts you found most interesting.






See notebook for an overview of common difficulties.

Click name to respond

Flag similarities closer than:

1 - 100 of 153 answers

Total of 7 responses sent to students for this assignment

| Student | Answer | Time | Response |
|---|--|-----------------------|----------|
|  | Vijay Gnaseh The derivation of equations for magnetic energy was tricky (33.8). What is the conceptual meaning of "dq" in the equations 33.30-33.31? red | 12/31/1969 6:59:59 pm | 0 / 1 |
|  | Jhon Yunog In section 33.7, it talks about how inductance. I'm still baffled as to exactly what inductance is. I understand that it is the constant of proportionality between the emf and the rate of change of current, but what is the practical application of knowing something like this? | 12/31/1969 6:59:59 pm | 0 / 1 |
|  | Ciha - Jnug Tasy The text relates different ways of calculating induced emfs, and finds that Faraday's Law tells us that the induced current produces a magnetic flux to counteract increases in flux through loops. Such applications have been used in toroidal coils. Have there been any other tested shapes of materials and technology that might better and more efficiently use the fundamentals of the law? red | 7/31/2000 12:00:00 am | 0 / 1 |
|  | Mici Artgia I did not find any part confusing. I found the concept of inductance to be most interesting because it provides yet another parallel between electrostatics and magnetism. | 4/6/2003 4:59:00 pm | 0 / 1 |
|  | Kroi Susear Undemeath equation 33.14 there is a note in parenthesis that says that the induced field is NOT an electrostatic field, and so the quantity calculated above is NOT electrostatic work. I understand that the field is different from a normal electric field since it's not created by discreet point | 4/7/2003 2:13:13 pm | 0 / 1 |

E-MAIL

Manage email connection

Email (3)

COMING UP

5/2 Assignment 1

TOOLS

Run Similarity Check

QUICK LINKS

Standardized tests

Students

Sections

Select Section

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[Report a problem](#)

SITE ADMIN

[Users](#)

[Conceptests](#)

[Topics](#)

[Bugs](#)

[Standardized test](#)

Preparing for class

Benefits:

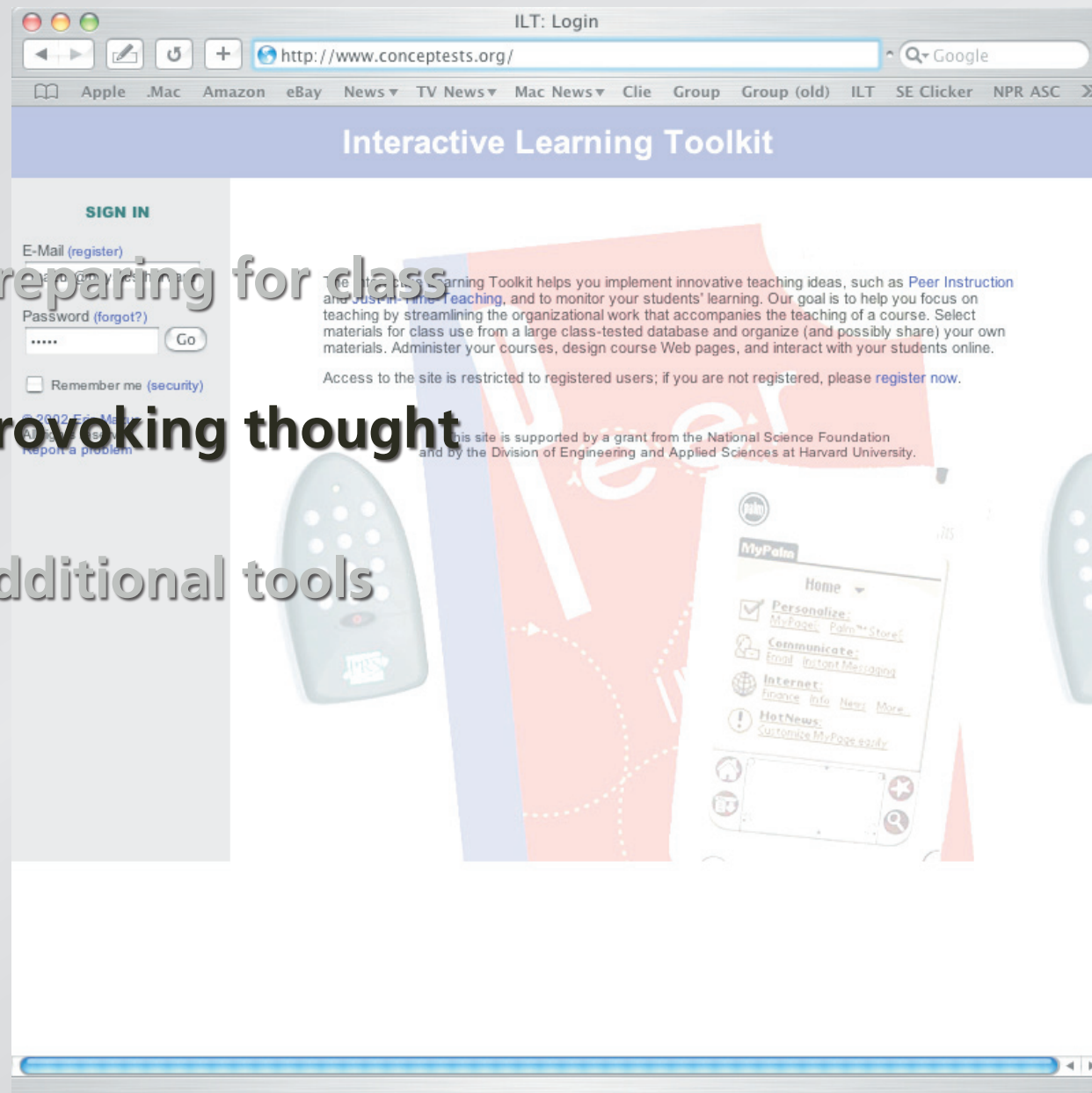
- prepares students for class
- helps instructor address individual student needs
- increases student-faculty interaction
- connects names and faces

The screenshot shows a web browser window titled "ILT: Students" with the URL "http://www.conceptest.org/". The page is for "Physics 1b" and is logged in as "Eric Mazur". The navigation menu includes "HOME", "READING", "LECTURES", "ASSIGNMENTS", "FORUMS", "NEWS", and "HANDOUTS". The main content area shows a forum post titled "Changing magnetic fields II" with a question: "Please tell us briefly what single point of the reading you found most difficult or confusing. If you did not find any part of it difficult or confusing, please tell us what parts you found most interesting." Below the question, there are controls for "Flag similarities closer than: 60" and "1 - 100 of 153 answers". A list of student responses is shown, each with a profile picture, name, and timestamp. The responses include:

- Shay Ghosh: "The derivation of equations for magnetic energy was tricky (33.8). What is the conceptual meaning of 'dq' in the equations 33.30-33.31?"
- Jhon Yunog: "In section 33.7, it talks about how inductance. I'm still baffled as to exactly what inductance is, understand that it is the constant of..."
- Ciha - Jnug Tasy: "The text relates different ways of calculating induced emfs, and finds that Faraday's Law tells us that the induced current produces a magnetic flux to counteract increases in flux through loops. Such applications have been used in toroidal coils. Have there been any other tested shapes of material and technology that might better and more efficiently use the..."
- Art...: "The part confusing, I found the concept of inductance to be most interesting because it provides yet another parallel between electrostatics and magnetism."
- Kroi Susear: "Underneath equation 33.14 there is a note in parenthesis that says that the induced field in NOT an electrostatic field, and so the quantity calculated above is NOT electrostatic work. I understand that the field is different from a normal electric field since it's not created by discreet point..."

Outline

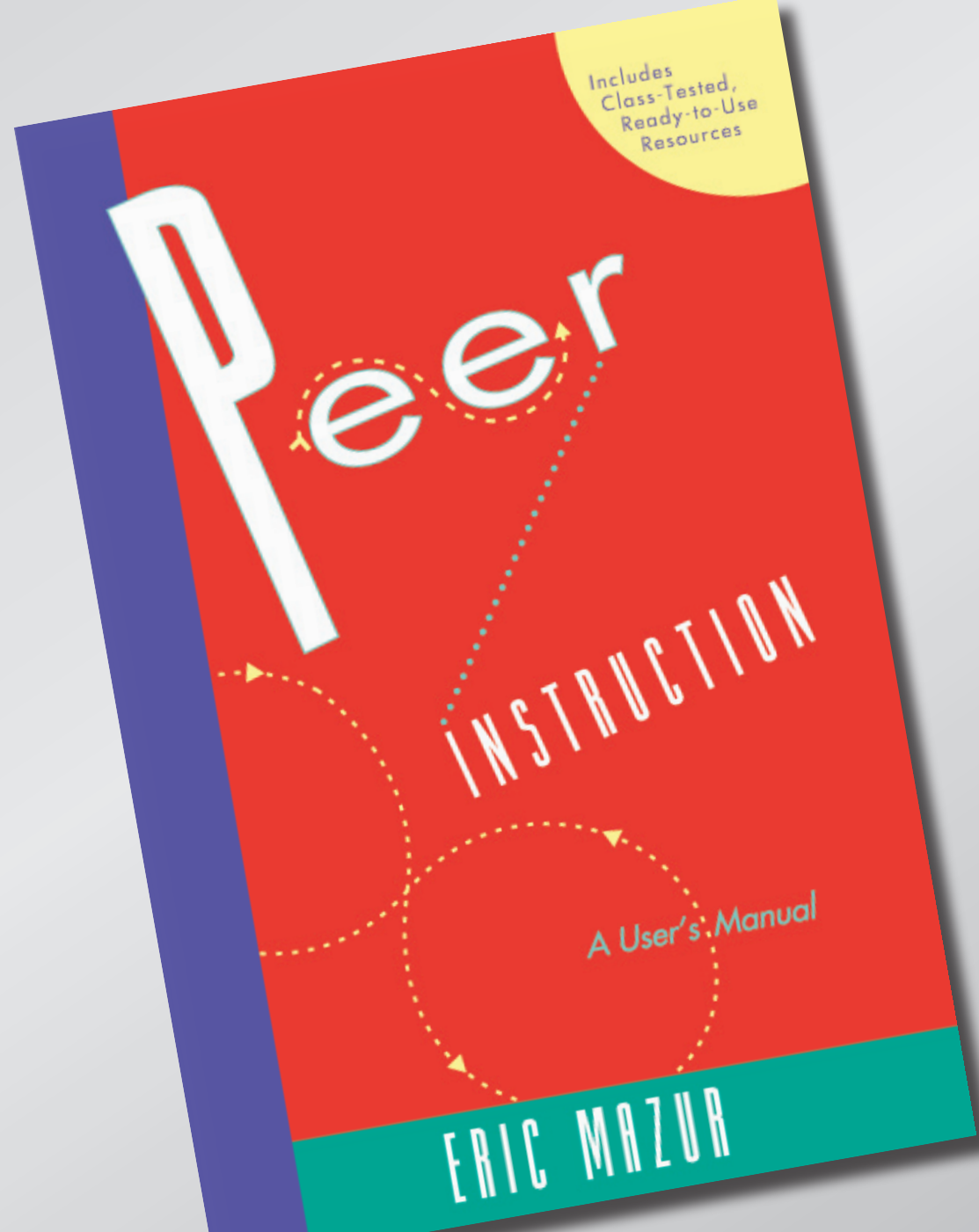
- preparing for class
- provoking thought
- additional tools



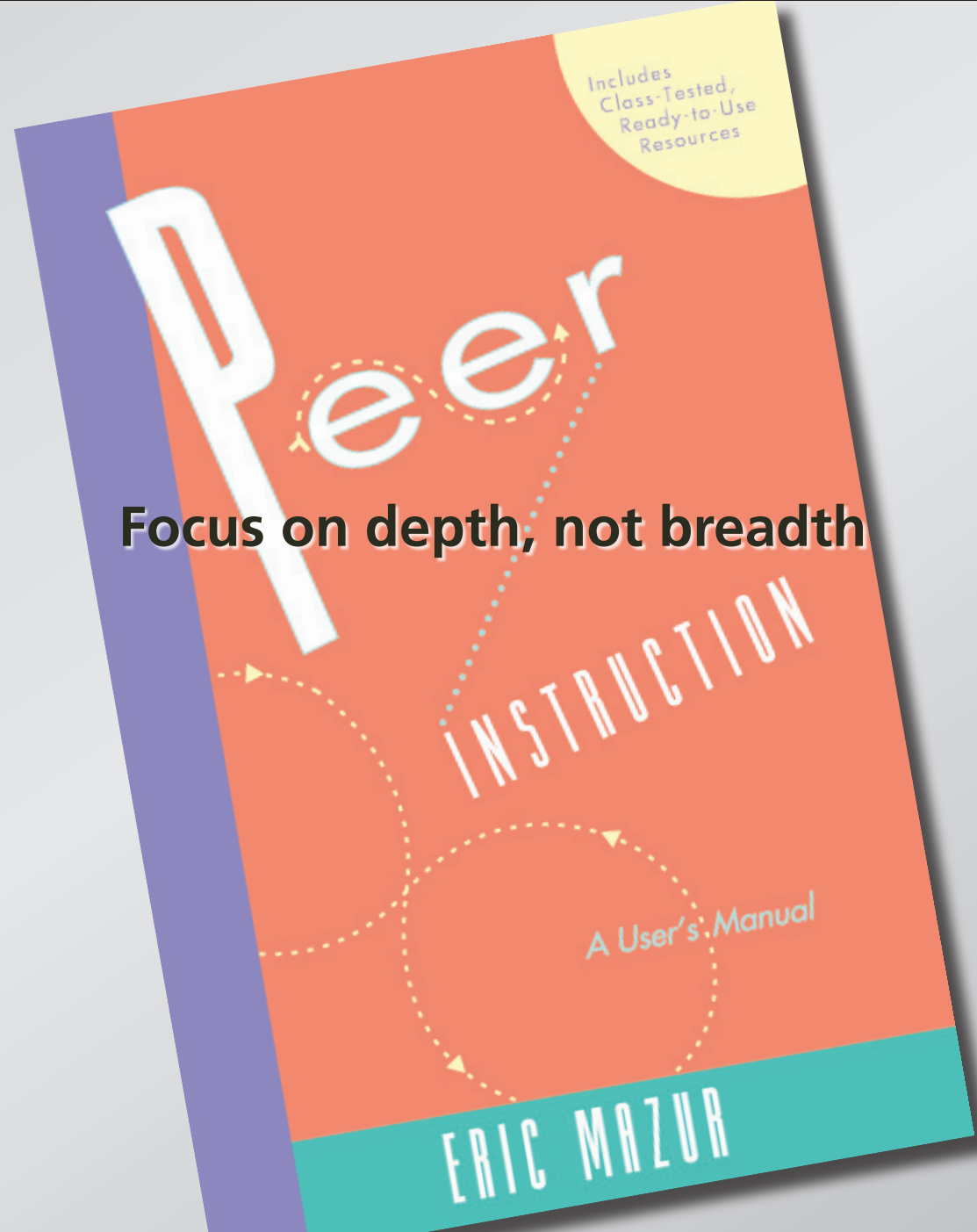
Provoking thought

What to do in class?

Provoking thought



Provoking thought



Focus on depth, not breadth

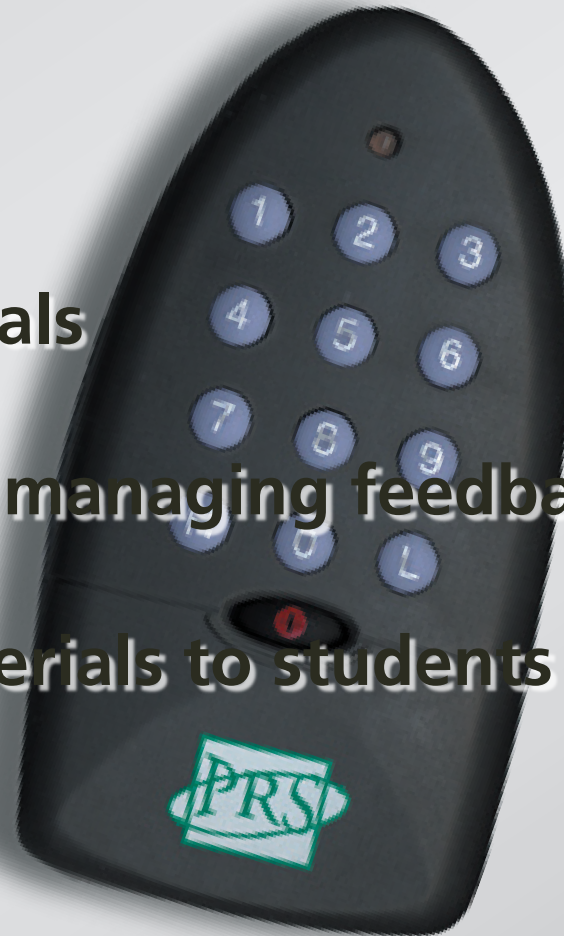
Provoking thought



Provoking thought

Some hurdles:

- finding materials
- collecting and managing feedback
- providing materials to students



Provoking thought

ILT: Manage

http://www.conceptest.org

ILT: Login local ILT: Lecture ILT: Reading

Physics 1b

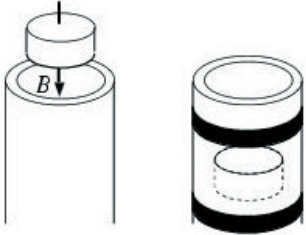
Logged in as Eric Mazur
Sign out

HOME READING LECTURES ASSIGNMENTS FORUMS NEWS HANDOUTS ?

Courses > Physics 1b > Lectures > |< < Changing magnetic fields II 4/8 > >|

edit clone ↑↓ 🔍 📊 Physics > Introductory Electromagnetism > Magnetism > CT: 3691
October 25, 2001 00:55:08 am

1. A permanent magnet is dropped through a long aluminum tube, as shown. As the magnet drops, electric currents are induced around the tube. Compared to a freely-falling magnet, the magnet through the tube drops



1. more slowly.
2. exactly the same way.
3. faster.
4. Need more information.


Hint: consider the effects of induced currents through strips ahead of and behind the dropped magnet.

Answer: 1. In a loop of the aluminum tube just below the magnet, the flux is increasing as the magnet gets nearer. This induces a counterclockwise current producing an opposing magnetic field which repels the magnet. In a loop above the magnet, the flux is decreasing, so a clockwise current is induced, producing a magnetic field in the same direction as the magnet's field, thus attracting the magnet upward. So the net effect is to slow the magnet down.

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Unpublished copyrighted material

edit clone ↑↓ 🔍 📊 Physics > Introductory Electromagnetism > Magnetism > CT: 3756
October 12, 2001 05:55:06 pm

2. Consider the arrangement shown below. Conducting rod AB is lying on a U-shaped conductor, making good electrical contact. The arrangement is placed in a magnetic field (into page).



Provoking thought

Benefits:

- easy preparation
- automatic student Web page generation
- management of data

The screenshot displays a web browser window with the URL `http://www.concepttest.org`. The page is titled "Physics 1b" and "Changing magnetic fields II 4/8". The user is logged in as "Eric Mazur". The page content includes a question about a magnet falling through an aluminum tube, a diagram of the setup, and an answer explaining the induced current and magnetic field. The browser interface shows the URL, search bar, and navigation buttons.

Physics 1b

HOME READING LECTURES ASSIGNMENTS FORUMS NEWS HANDOUTS ?

Courses > Physics 1b > Lectures > < Changing magnetic fields II 4/8 > >|

Physics > Introductory Electromagnetism > Magnetism > CT: 3691
October 25, 2001 00:55:08 am

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Click for more information.

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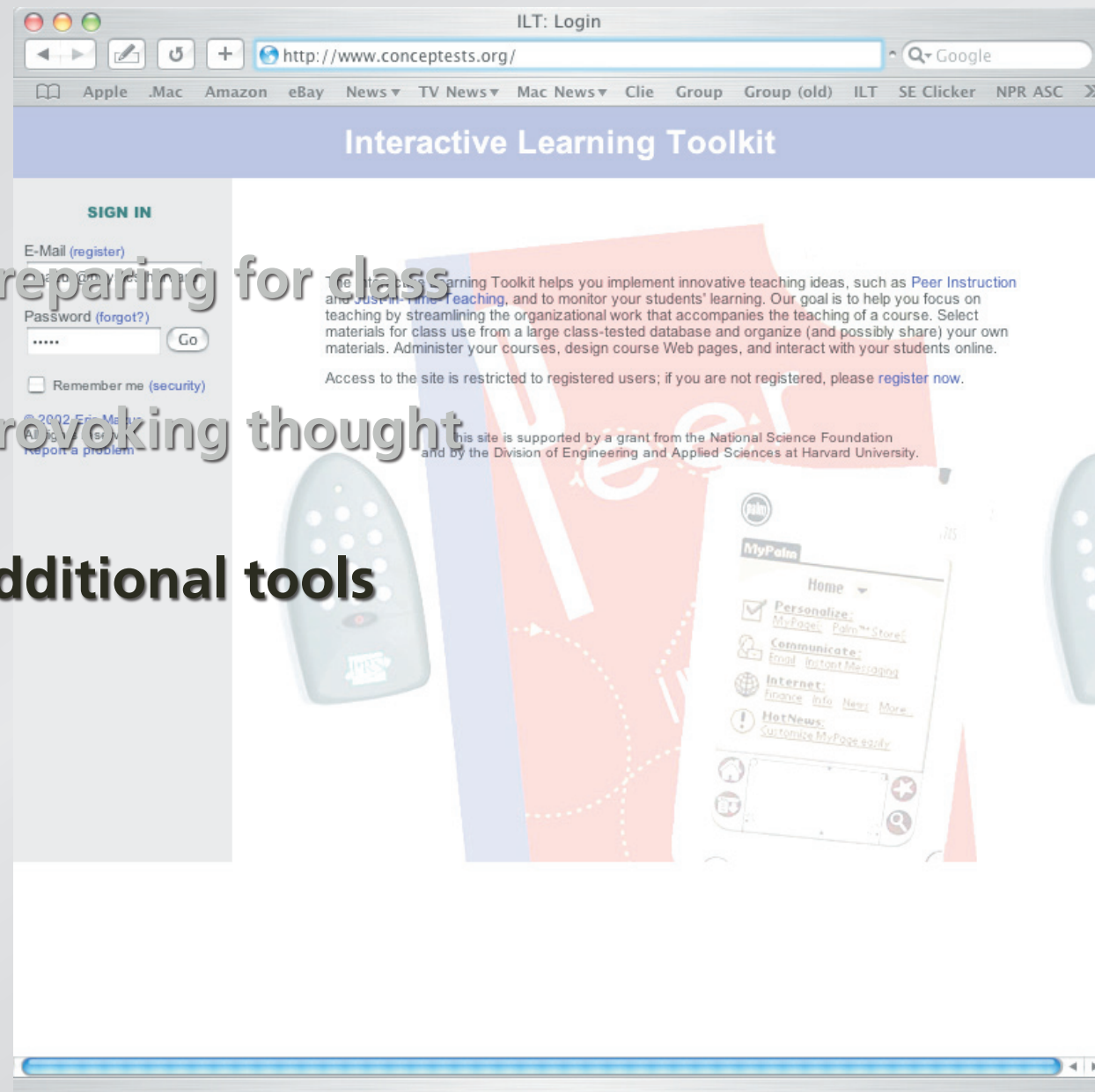
Copyright © 2000, Eric Mazur
Unpublished copyrighted material

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October 12, 2001 05:55:06 pm

2. Consider the arrangement shown below. Conducting rod AB is lying on a U-shaped conductor, making good electrical contact. The arrangement is placed in a magnetic field (into page).

Outline

- preparing for class
- provoking thought
- additional tools



Additional tools

- forums
- e-mail
- gradebook
- cloning
- reminders

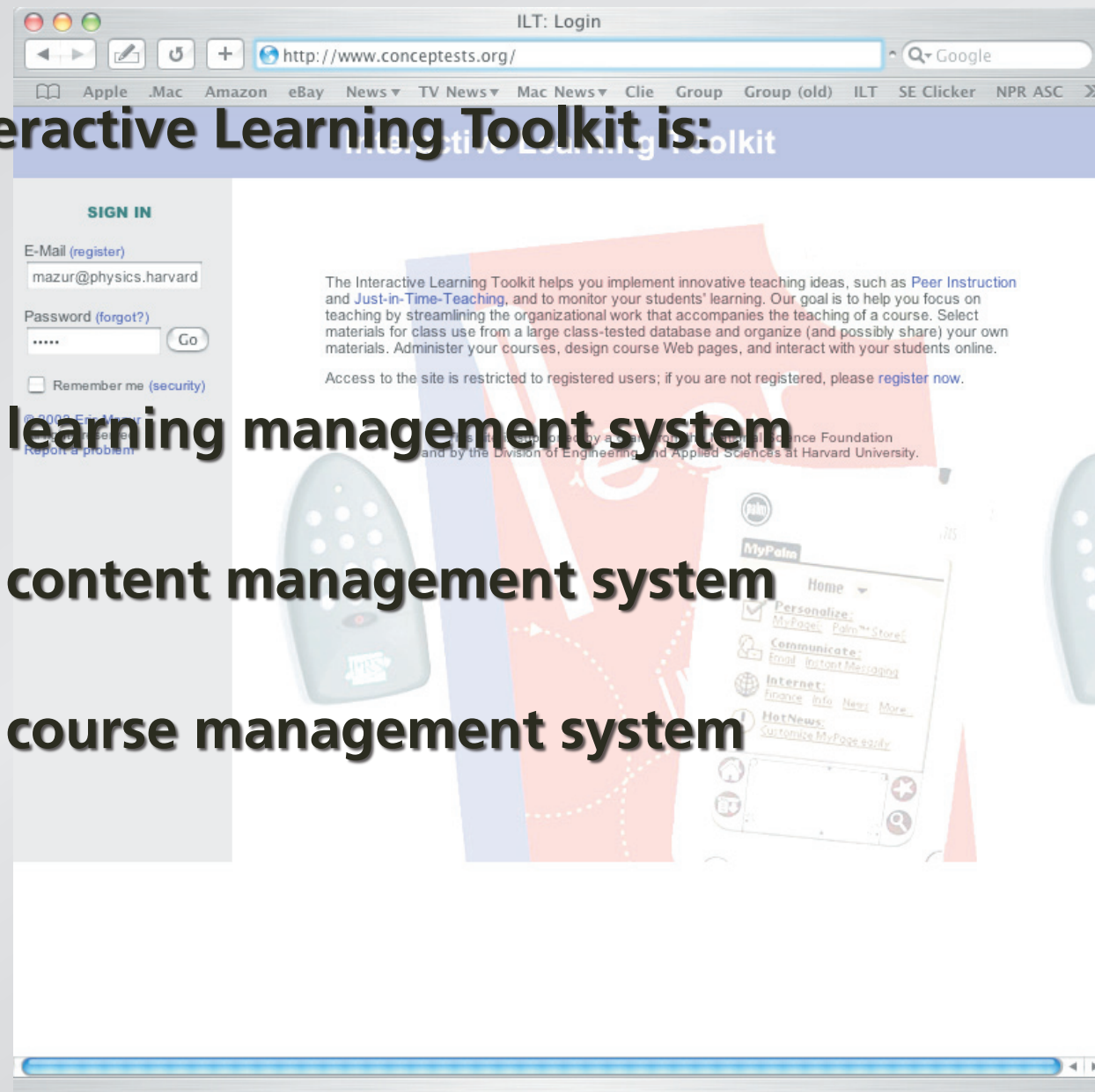
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and much more!

Additional tools

Interactive Learning Toolkit is:

- a learning management system
- a content management system
- a course management system

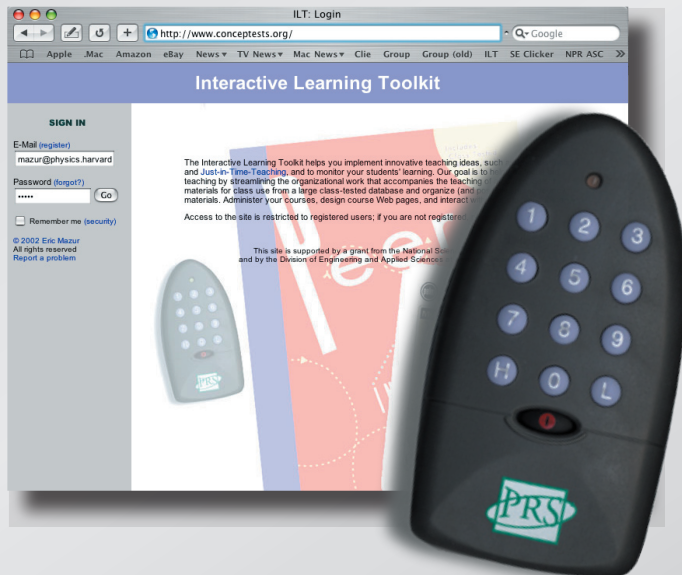


Additional tools

Resources:

ILT video (www.ankerpub.com)

Books on PI and JiTT (Prentice Hall)

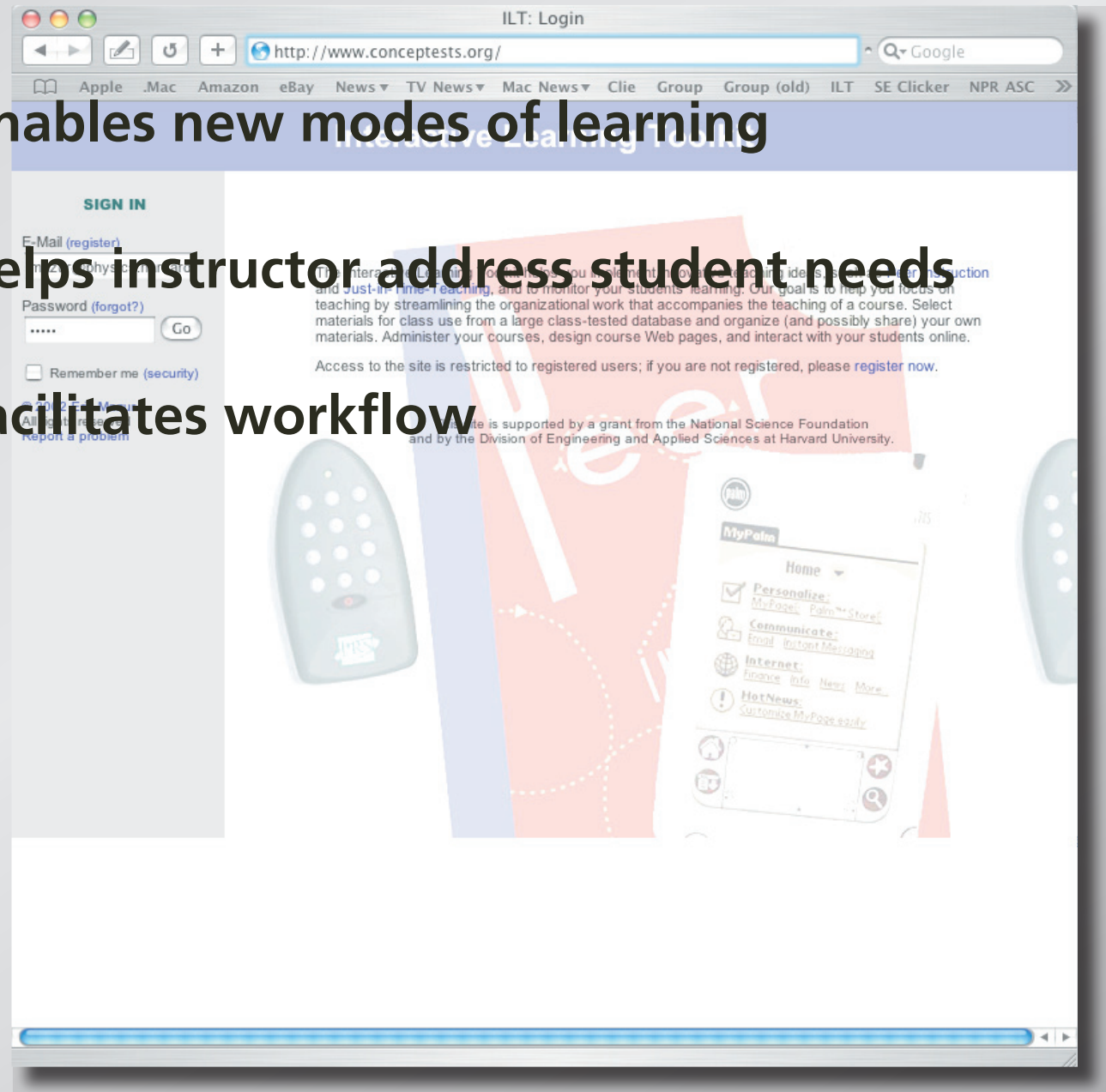


ILT site:

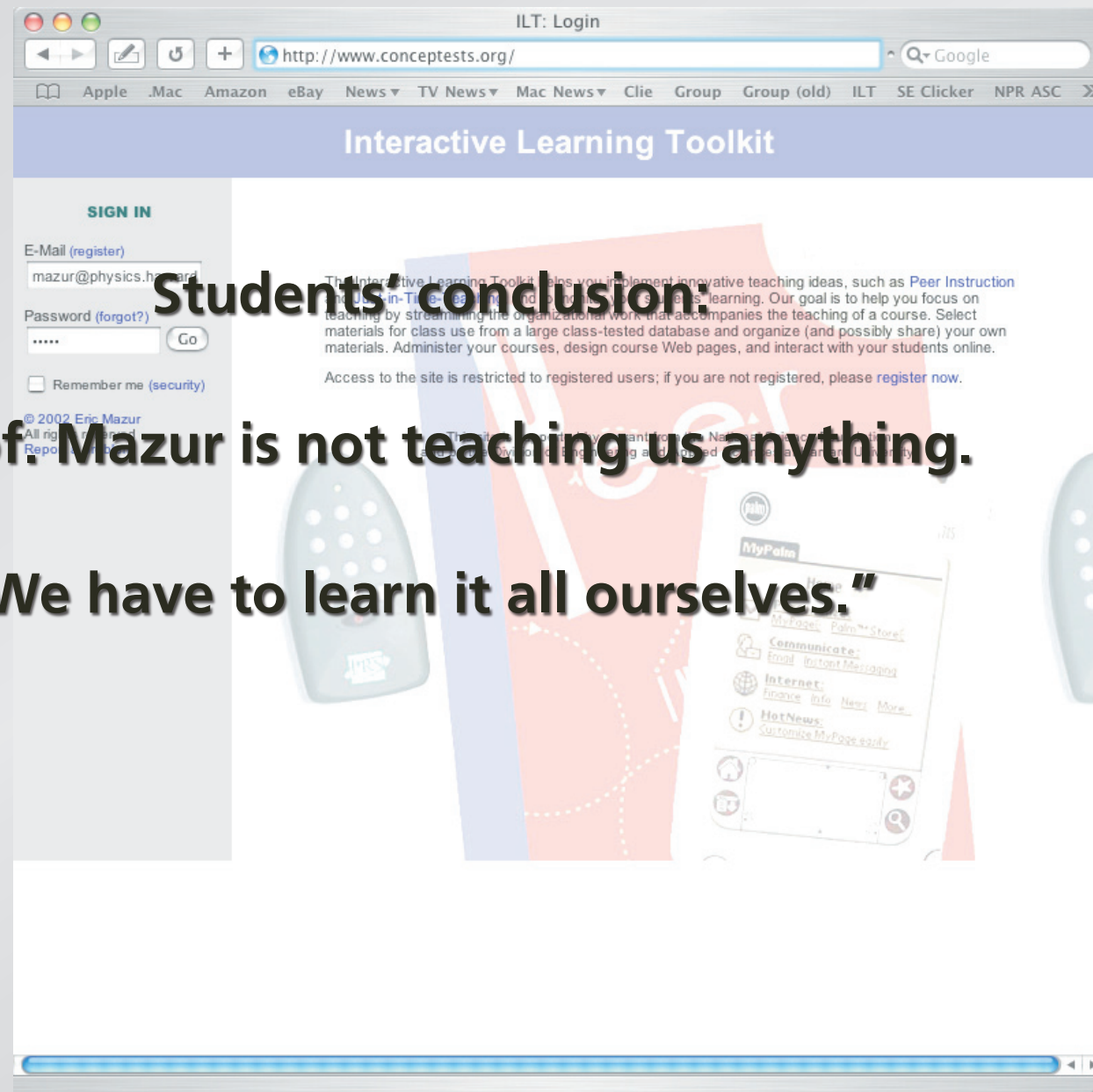
deas.harvard.edu/ilt

Summary

- enables new modes of learning
- helps instructor address student needs
- facilitates workflow



Summary



Students' conclusion:

“Prof. Mazur is not teaching us anything.

We have to learn it all ourselves.”

Support:

NSF-Distinguished Teaching Scholar Award
NSF-Assessment of Student Achievement Award
Harvard DEAS Information Technology Group

Prentice Hall
Apple Computer

for a copy of this presentation:

<http://mazur-www.harvard.edu>

