Practical strategies for encouraging interactive learning in upper-level physics courses

shifting the focus from teaching to learning

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Seminar overview

I. My teaching goals

II. Strategies for eliciting broad class involvement
- a. Course design
- b. Classroom approach
- c. Evaluating student progress

III. Managing difficult situations

IV. Simple things YOU can try

My teaching goals

* Promote student interest in course topics

to attract majors, summer researchers, and grad applicants.

* Encourage working knowledge rather than recitation

to prepare students to think on their feet and appreciate real-world science.

* Develop course frameworks which can be used year after year

to help balance teaching with other responsibilities.

Influences

* **Peer instruction in the lecture setting**

Eric Mazur (Harvard University)
galileo.harvard.edu/home.html

10 minute mini-lectures, 5 minute questions

Al Slavin, Trent University
"Peer learning in the large-lecture setting." Physics in Canada (March-April, 2005)

mini-lectures among short and long questions

* **Experiential learning**

MUN Physics & Physical Oceanography
http://maxwell.physics.mun.ca/mpl/Physics1054/home.html

integrated mini-lectures and lab activities

Context

PHYS 3400 "Thermodynamics"

3rd year required course, historical enrollment 20-30 students
draws on 2nd year thermal and quantum physics
no lab component

Challenge: Using partial derivatives in physics contexts

PHYS 4000 "Introduction to Solid State Physics"

4th year elective, historical enrollment 3-12 students
draws on many subdisciplines
closely associated with my research interests

Challenge: Introduce breadth (and some depth) of CMP

Course design: integrating interaction

* Choose textbook that students can use

 Concise is better than long-winded (readability).
 Examples/problems can save you time (especially with solutions!).

* Build regular written feedback opportunities into course

 Submitted electronically each week.

* Use a variety of evaluation methods and integrate them

 Class presentations, analyzing journal articles, and preparing web pages can supplement problem sets.
 Problem sets can guide students toward special topics projects.
 Quizzes or multiple midterm tests encourage consistent effort throughout term.

Classroom approach

EXPECT STUDENTS TO READ BEFORE COMING TO CLASS

* Question-directed class meetings
  - definitions, equations
  - key concepts
  - short quantitative problems
  - longer (problem set type) questions
  - comparisons and "big picture" contexts
  - discussing data from scientific literature

* Supplement textbook information in class meetings
  - recent journal articles
  - web examples
  - student requests

EXPECT STUDENTS TO READ BEFORE COMING TO CLASS

Reading responses

Reading response #1

Name: Kristin Poduska (Preview)
Start time: September 4, 2003 10:50
Number of questions: 4

Finish | Help

Question Status

- Unanswered
- Answered
- Answer not saved

1	2	3	4

Question 1 (1 point)

Crystal systems

Which of the following is NOT a type of crystal system?

- a. Hexagonal
- b. Trigonal
- c. Tetragonal
- d. Pyramidal

Save answer

Question 2 (1 point)

Miller indices

How many (unique) indices are required to specify an atomic plane in a 3D crystal?

- a. 2
- b. 3
- c. 4
- d. 5

Save answer

Question 3 (1 point)

Atomic packing

Which of the following terms relating to atomic packing are equivalent?

- a. face-centered cubic and cubic close packed
- b. cubic close packed and hexagonal close packed
- c. hexagonal close packed and face-centered cubic

Save answer

Question 4 (1 point)

Points to clarify

What concepts, derivations, or explanations need the most clarification for you? (The more specific you are, the more directed the class meetings will be.)

Class exercises

definitions, equations, key concepts

Which of the following expressions for electrical conductivity are correct?

(a) j/E

(b) $1/\rho$

(c) I/RA

(d) $n e \mu$

(e) $n e^2 \tau / m$

* Ask students to

1. think on their own for a few minutes,
2. discuss with students nearby, then
3. regroup as a whole class.

THINK, PAIR, SHARE

Class exercises

short quantitative problems

Using a cube,

* find the [100], [110], and [111] directions.

* find the (100), (110), and (111) planes.

What is the distance between (111) planes?

(from Al Slavin)

* Visual aids, tangible objects, videos, or demonstrations can

focus student efforts,
keep student interest and attention.

* Post notes on web just before or after class, for the element of surprise.

Class exercises

Longer (problem set type) questions can benefit from parsing.

Define relevant concepts, identify useful relations, derive equation and sketch result.

Calculate the vibrational density of states g(omega) for the periodic one-dimensional, monatomic chain.

Identify important aspects of alternative model and compare results.

Compare, by means of a sketch, its behaviour with that of the Debye density of states of an elastic continuum.

Modify pertinent equations to accomodate the new situation and compare results.

How does the behaviour change for the linear di-atomic chain model?

Class exercises

comparisons and "big picture" contexts

Which is the most likely cause of electron scattering in a metal at room temperature?

(a) electron-electron scattering

(b) electron-defect scattering

(c) electron-phonon scattering

* Variations:

Take a class vote, then solicit justification for a student's choice.
Distribute choices among students and ask each group to reword the question to make their choice the correct one.

Class exercises

Use data from scientific literature.

The figure below shows the temperature dependence of electrical resistivity for CeSbTe. Is this material a metal, semiconductor, or insulator?

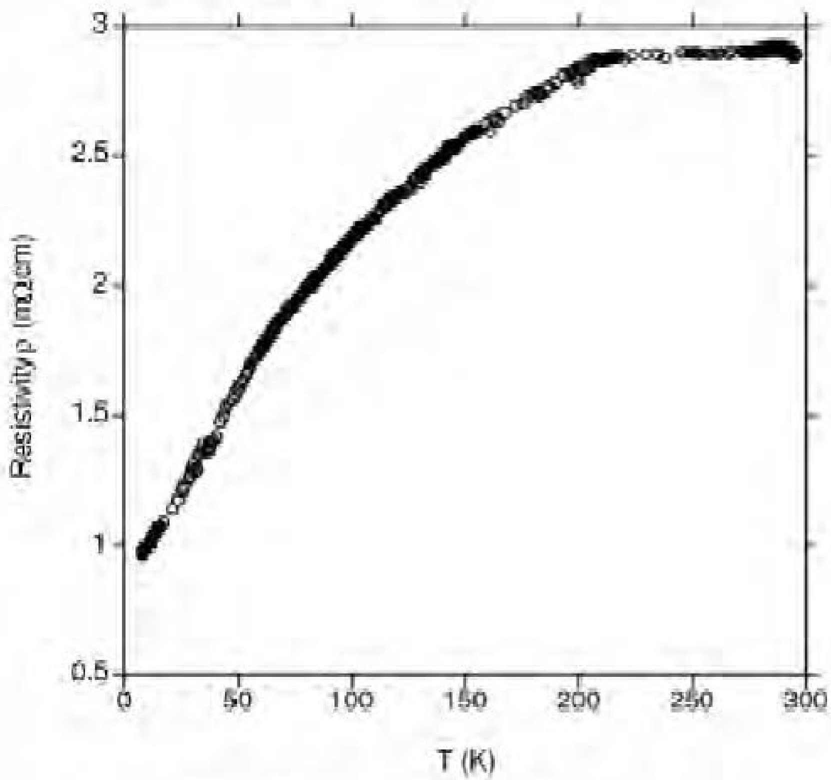


Fig. 6. Electrical resistivity as a function of T for CeSbTe.

Y.C. Wang et al. / Journal of Alloys and Compounds 314 (2001) 132–139

For the trying times...

Identify why class meetings don't meet expectations

* The shy student

    will talk in smaller groups or if prompted.

* The underprepared student

    will talk, but can't contribute at expected level.

* The reluctant student

    doesn't want to talk at all.

No one approach is effective for all students on all days, but using a variety of approaches <u>consistently</u> can help.

Student feedback

comments from my first end-of-term (anonymous) questionnaire

What do you enjoy most about the course?

"the class structure"

"the class discussions"

"the lack of traditional lectures"

"the interaction in class"

"...a lot of information available"

What do you find most frustrating about the course?

"It's hard to find time to sift through it all and find what we need."

"There is a lot of reading with confusing math added in."

"Certain (small) aspects of the course are best presented in a lecture."

"lack of computational examples"

Small things that can make a difference

(Remember the number that you picked?)

1. Require each student to say something at the beginning of class.

2. Give students slips of paper at the beginning of class which relate to a later activity.

3. Give a cut-and-paste derivation to assemble as a group/class.

4. Make students sit in different seats or change seats during class.

5. Use reading response questions to start off a class.

6. Do a demonstration which involves students.

7. Use a stack of name cards to call on students throughout term.

8. Ask for student feedback during the term (rather than only at the end).

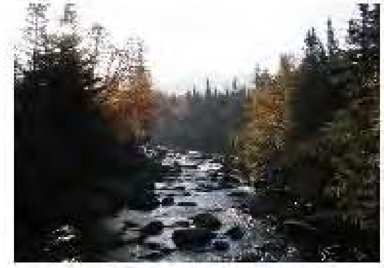
Summary

* Interactive learning strategies help me meet my teaching goals

  Promote student interest in course topics
  Encourage working knowledge rather than recitation
  Develop course frameworks which can be used year after year

* Interactive learning can be implemented within a standard course framework

* Students appreciate a break from traditional lectures

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