New Science Faculty Workshop

2 Implementing principles of learning

summarize bunch of research-- sources,
a. refs on cwsei website, b. will list a few later, c. ask me
d. ask stIfs in your department if in CWSEI

goals for today

1. You will be able to design questions and problems that will get students intellectually engaged and doing critical thinking. (= “thinking”)
a. you will be able to identify the specific elements needed to go into the design.
b. you will recognize what research says about how traditional lecturing & exams often discourage student thinking.

2. You will be able to find things you can do that will allow you to teach more efficiently
(= less time for you and more learning by students)

time saving tip #1-- **Start** by identifying your learning goals. Prep time much more efficient.

Principles of learning:

#1-- all learning involves connecting up with and building on prior thinking and knowledge base

#2 Motivation to learn is essential. Is necessary element of teaching.

#3-- engagement. People must think hard about a subject to learn it.

#4 Need effective feedback--Guidance that shapes thinking and learning.

#5 Expert thinking involves more than knowing information, is also how information is organized, applied, and learned.

#6 Working memory extremely limited capacity!
More demands on it, less learned.

#7 Retention by spaced repeated retrieval & multiple associations

What is the single ***most*** important element needed for an instructor to teach a science topic effectively?

a. clarity

b. motivate students.

c. engagement

d. charisma and/or trust (personal characteristics)

e. feedback and guidance

what is the right answer?

(?) b. motivate students.

how to motivate students to want to learn topic and be intellectually engaged?

Task:

form mixed discipline groups, pick topic one is teaching

Think of specific way(s) could achieve motivation in
a. classroom
b. on homework
c. on exams

will then discuss

First-- data about what is “taught” about purpose of course and how to learn

Beliefs about physics/chem and problem solving

Novice

Content: isolated pieces of information to be memorized.

Handed down by an authority. Unrelated to world.

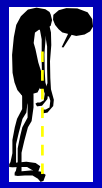
Problem solving: pattern matching to memorized recipes.

Expert

Content: coherent structure of concepts.

Describes nature, established by experiment.

Prob. Solving: Systematic concept-based strategies. Widely applicable.

~10% 

% shift?

intro physics & chem courses ⇒ *more* novice

ref.s Redish et al, CU work--Adams, Perkins, MD, NF, SP, CW

*adapted from D. Hammer

examples of survey statements on which students are being taught to think less like experts

I am not satisfied until I understand why something works the way it does.

I do not spend more than five minutes stuck on a physics problem before giving up or seeking help from someone else.

Understanding physics basically means being able to recall something you've read or been shown.

Knowledge in physics consists of many disconnected topics.

If I get stuck on a physics problem on my first try, I usually try to figure out a different way that works.

In doing a physics problem, if my calculation gives a result very different from what I'd expect, I'd trust the calculation rather than going back through the problem.

In physics, it is important for me to make sense out of formulas before I can use them correctly.

how to motivate students to want to learn topic and be intellectually engaged?

form mixed discipline groups, pick topic one is teaching

Think of specific way(s) could achieve motivation in
a. classroom
b. on homework
c. on exams

discuss

-- “trust me so will believe should learn because will be useful later” discussion

methods and techniques then ⇒ problems to be solved with them

“Disembodied knowledge”

Manual for using computer program before seeing program.
Understand the words, but no meaning

Knowledge only meaningful and useful with contextual assoc.
Associations with how used essential

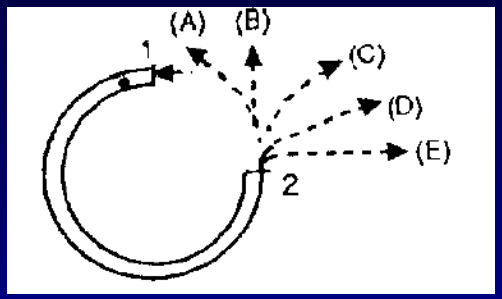
2. Getting them to think

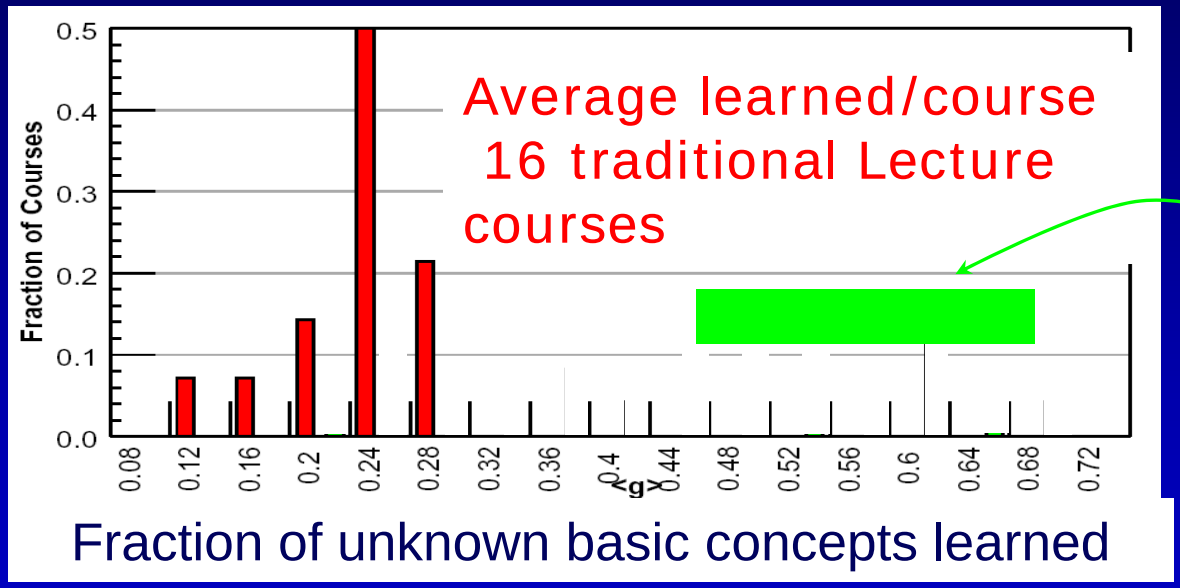
Will explore how to do.

First--
Research on how well students learn an aspect of this, understanding and applying physics concepts, from being told them (traditional lecture) and doing standard homework problems.

II. Force Concept Inventory- learning basic concepts of force and motion 1st semester physics

Ask at start and end of semester--
What % learned? (100's of courses)





interactive engagement methods

On average learn <30% of concepts did not already know.
Lecturer quality, class size, institution,...doesn't matter!
Similar data for other physics courses & biology.

R. Hake, "…A six-thousand-student survey…" AJP 66, 64-74 ('98).

2. "Getting them to think"

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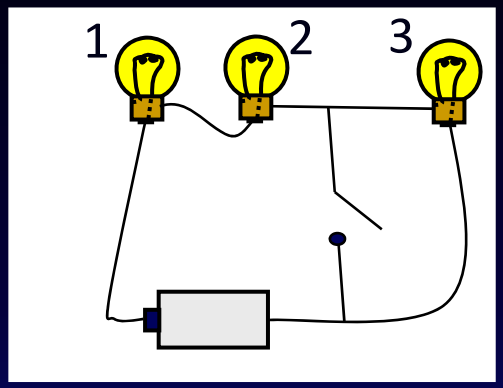
What aspects of your discussion & thinking on this question were "critical thinking"?

- analysis of what was important, what wasn't
- analysis of relationships of different aspects of question
- choices and judgments
-
-
-

model for questions that have students think--
questions or problems that directly call upon these kinds of processes. Model and practice "thinking".

example: concept questions used with clickers-- intro physics--



When switch is closed,
bulb 2 will
a. stay same brightness,
b. get brighter
c. get dimmer,
d. go out.

What are the elements that make this a good question for getting students to think?

- familiar situation & elements-- makes sense & semi-relevant
- clear task
- requires "expert" model of electric current flow
- conceptual reasoning
- have them discuss then present arguments-- you can "coach" them on thinking

model of thinking task can use in class

- pose question
- student-student discussion
- broader discussion of answers and reasoning
- instructor guidance as to best thinking

-- follow up explanation and additional information

- student questions

“preparation to learn”

1. Present problem to be solved (and why worth solving)
2. Have students think about how to solve, what relevant and not, ... [“Teaching Expert Thinking]
3. Then tell solution methods, with reasoning

$\Rightarrow$ sticks a lot more

Principle of learning #5 Expert thinking involves more than knowing information, is also how information is organized, applied, and learned.

Develops only with active and explicit construction to change how brain is "wired" .

To teach, provide tasks that require practicing expert-like thinking--recognizing patterns, modeling, making connections, organizing information around concepts, transfer to new situations, ...
"Teaching Expert Thinking" 2 pg CWSEI guide-- handout

Harder and more important to learn and longer lasting than facts.

Have to not just teach *what* to learn, but also *what is* real learning, and *how* to learn!

Time saving tip-- if students spending time working on such task, you spend less time preparing material to tell them. And they learn more!
If can get questions or activities from someone else or web, saves even more.

Time saving tip-- if require students to read, so frees up class time for "thinking practice" activities, also means you do not have to spend lots of time distilling down textbook for them. You explain better than author?
(be realistic about amount of reading & depth of understanding expected)

specific classroom technique-- “peer instruction”

1. Students preread (brief quiz, online or clickers in class)
2. ~ 5 major questions or activities. Can have answer on own, then discuss and answer again.
Can be working through problem solution-- next steps, reasons for decision, arguments for interpretation or conclusion ....
3. Must have some form of accountability for students. Simplest with clickers, but could be written activity that turn in. (“*create analogy for... Explain why is good analogy, why it is imperfect.”, design a ..., solve problem, do proof, ...*)
4. Follow up discussion that specifically addresses questions or issues that came up. Encourage students to express reasons or arguments. Generates much more engagement, student questions.
5. Make homework and exams align with questions.

Task-- come up with idea for good question or activity

Important elements in interactive engagement

1. not simple yes-no questions, numerical answers predicting, modeling, analyzing

2. Accountability

   $\Rightarrow$clickers, turn in paper with names, index cards, ...

3. Feedback-- discussion that “coaches” thinking

If you are emphasizing teaching thinking, not just being a source of information, then when don't know something will not be seen as failure.
If not know, show how you would figure out or find out.
Enlist students to help-- useful skill.
But-- must make explicit what teaching and why.

saves preparation time--don't have to know everything
(but if learning because need to know-- then is not teaching time, is learning time)
If not see good reason to learn other than to teach it, is it really that important for students to learn?

Other important elements in getting them to think

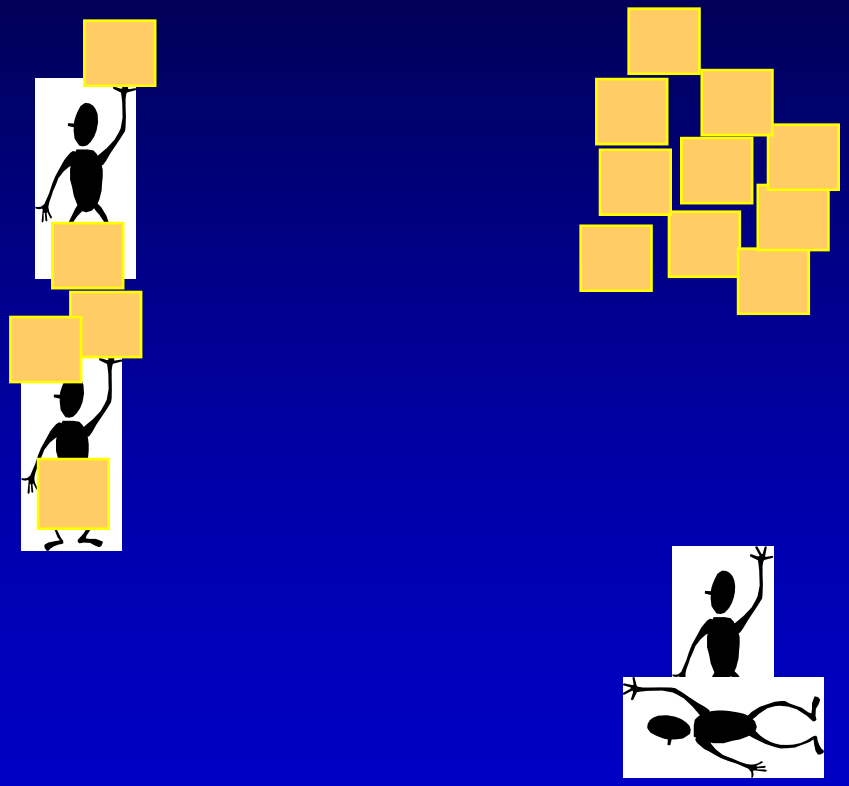
1. make sure you explicitly display thinking while explaining and presenting material.

2. make sure demonstrating/explaining thinking and reasoning part of all assignments and exam questions. Have marks attached.

3. don’t ask questions that cannot be solved without thinking

4. ???

Reducing unnecessary demands on working memory leaves them with some capacity left for processing.



Reduce unnecessary demand on working memory aids learning.
How accomplish?

Reducing demands on working memory:

Eliminate unfamiliar jargon or extraneous information.

Translation of words into image or process.

Connect new information or ideas to stuff in long term memory (show where is same or closely related to previous ideas, **analogies**, ...)

Showing organization and relationships ("chunking")

practice task--
come up with two analogies for how people learn

CWSEI

Creating, testing, saving good materials.
(repository of information)
Saving time, improving learning.

if time

Useful retention

Principle of learning #7 Requirements for retention well established.

1. Spaced, repeated retrieval and application ("testing"/using)

2. Multiple associations ("hooks") with stuff in long term memory
   (more the better, "useful" associations--expertise)