How thinking about thinking can improve teaching
Carl Wieman

Basics – choosing homework problems and reviewing past material

I. Homework that practices & builds scientific expertise

5 minutes for questions

II. A better way to review material in class – theory

III. A better way to review material in class – demonstration
Jane Maxwell

<u>Some components of scientific expertise</u> (thinking like a scientist)

- concepts and mental models + selection criteria
- recognizing relevant & irrelevant information
- what information is needed to solve
- does answer/conclusion make sense- ways to test
- **model** development, testing, and use
- moving between specialized representations (graphs, equations, physical motions, etc.)
- …

Only make sense in context of topics.
Knowledge important but only as integrated part- *how to use/make-decisions with that knowledge.*

What is practiced and assessed on typical homework problems

- Provide all information needed, and only that information, to solve the problem
- Say what to neglect
- Not ask for argument why answer reasonable
- Only call for use of one representation
- *Possible* to solve quickly and easily by plugging into equation/procedure

- ~~concepts and mental models + selection criteria~~
- ~~recognizing relevant & irrelevant information~~
- ~~what information is needed to solve~~
- ~~How I know this conclusion correct (or not)~~
- ~~**model** development, testing, and use~~
- ~~moving between specialized representations (graphs, equations, physical motions, etc.)~~

Doing better--HW that practices expertise (various options)

1. Provide necessary and unnecessary information in problems
2. Provide information in one representation, require it to be translated into other representations to solve problem.
3. *What information is needed to solve this problem (info not given)?*
4. *Estimate or find the numbers you need– justify estimates.*
5. *What concepts apply? Explain why.*
6. *Give criteria for judging if your answer makes sense. Show how they apply.*
7. *Identify what approximations should be used in solving this problem, justify that those approximations are reasonable.*

good to ask about any place where expert/scientist makes decisions

- concepts and mental models + selection criteria
- recognizing relevant & irrelevant information
- what information is needed to solve
- does answer/conclusion make sense- ways to test
- **model** development, testing, and use
- moving between specialized representations (graphs, equations, physical motions, etc.)

"But that would only work for small classes, lots of marking help…"

Not so– computer graded examples (<u>very</u> multiple choice)

– *Select which concepts from this list apply*
(list all in course, same every problem set)

– *Which features of problem (or context) important for deciding?*

– *Select which criteria would be useful for checking if answer makes sense* (list all, some useful, some not)

– *Which information is needed to solve problem* (long list—can use for all problems)

– *Provide estimate for the value of … [insert number in units of kg]*

– *Match each of this set of graphs to the correct description of the behaviors they represent.*

– *Rank …*

- concepts and mental models + selection criteria
- recognizing relevant & irrelevant information
- what information is needed to solve
- does answer/conclusion make sense- ways to test
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II. A better way to review material in class—theory

Lots of time is spent in review – one course to next, one class to next

The Usual – *"You have seen this before, but I will just go over quickly to remind you."*

Louis Deslauiers (and then other STLFs)–
"Students are tuning out during your review."

me -- **Mais oui!!**

Basic cognitive psychology!

- Familiarity produces false sense of understanding
- Hearing somebody tell you something you think you already know—**boooring!!**

and if not familiar with it, student can never follow fast review

How to do better?
Don't review, test!

Series of clicker questions covering the review material

Students have to actively process, **checks** if they know or not.

Get wrong—teacher knows
student knows, pays attention to explanation

All get right—teacher knows, doesn't waste time retelling

Testing then telling– good. But can we do even better?
More targeted telling and encourage more reflection on understanding of topic?

Isn't that what happens in a two stage exam?

Two stage exams– used widely in sciences at UBC

Stage 1 – students write exam individually and turn in
Stage 2 – students write exam again in group, turn in.
Learning experience

Maybe try version of this for review?

Jane Maxwell - STLF UBC Chemistry Department

Two-stage review
Jane Maxwell

The context

- CHEM 311: Instrumental Analysis
- Demographics:
  - Chemistry majors and honours (~90 students)
  - Bachelor of Medical Lab Sciences (~25 students)
- **Challenge:** Significant variation in students' background knowledge
  - Unclear prerequisites
- First day of class: not much happens

Why use a two-stage review?

Goals:

1. Snapshot of students' understanding of key concepts

2. Provide immediate feedback & clarification on their background knowledge

3. Mix the two student cohorts

4. Have a productive first day of class!

Developing the two-stage review activity

1. Identify the topics and key concepts
   - Brainstorming with instructor, lecture TA, and STLF
   - Topics and concepts from prerequisites

2. Develop a set of multiple-choice questions (18 Qs)
   - targeted at a "quiz" level rather than "final exam" level

Example: Which of the following photons travels through space with the highest velocity?

a. Infrared
b. Red
c. Green
d. Blue
e. The velocities are all the same

The first day of class: Organization

- Students assigned to groups of 5
  - rearranged into groups during a 5-minute break
- **Individual review**: Scantron sheets, 15 min
- **Group review**: "Immediate Feedback Assessment Technology" (IF AT) cards, 15 min

Repeatedly emphasized was <u>not</u> for marks

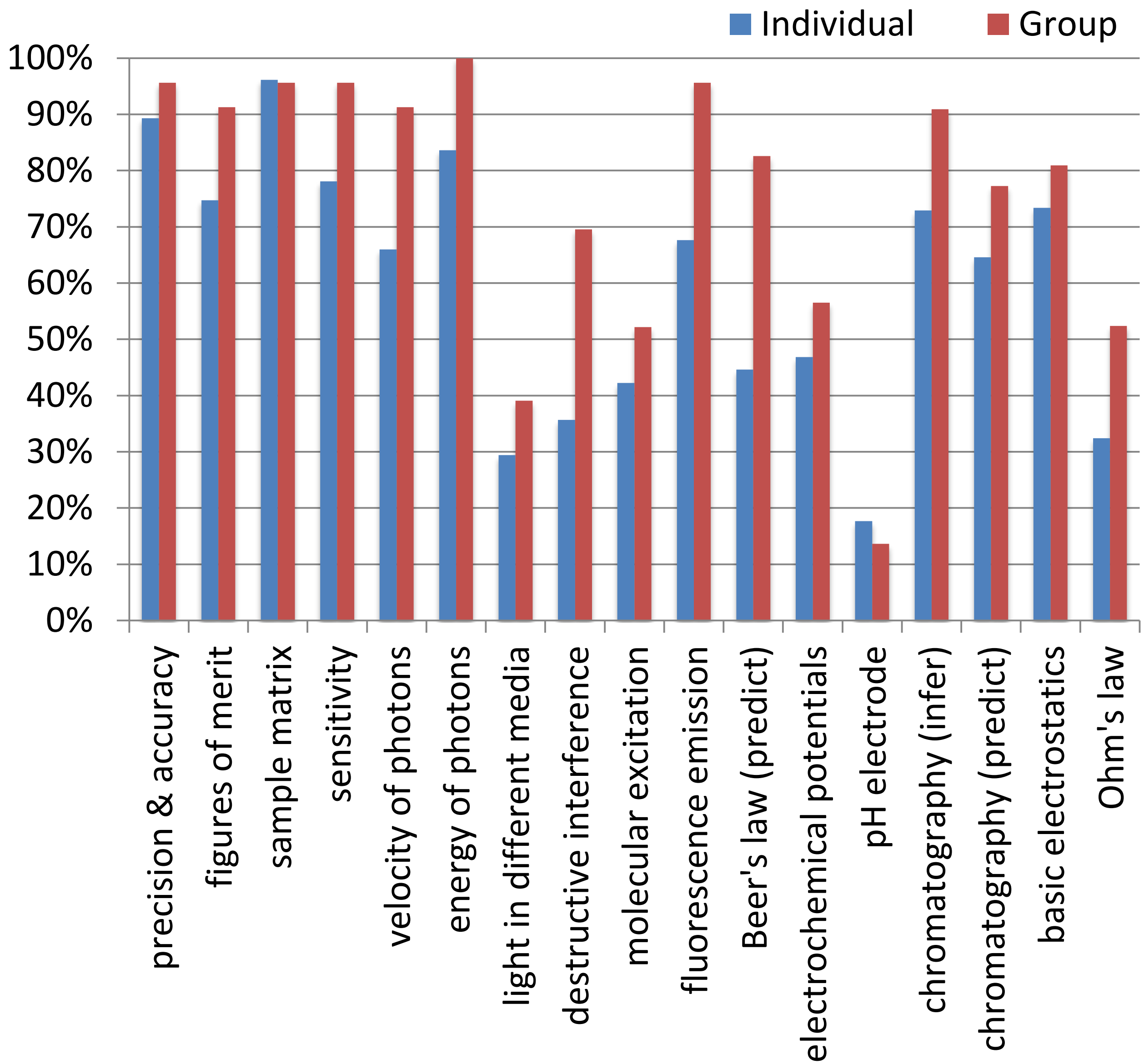
- Afterwards: Explanations of correct & incorrect answers posted on Connect

http://learnification.wordpress.com/2011/03/23/two-stage-group-quizzes-part-1-what-how-and-why/

The first day of class: How did it go?

- Groups appeared engaged in good discussions
- Rushed, but nearly all groups finished (some stayed late to finish)
- Positive attitudes during and afterwards ("That was fun!")

What we learned: Strengths and weaknesses



What we learned:

3 categories of questions:

1. Majority correct – students receive feedback from peers →100%
2. Majority *in*correct - target for clarification by instructor
3. Majority of *groups* incorrect – identify widely-held misconceptions

Lessons for future implementation

- **Easy to prepare and implement**
- Important in our case to maximize heterogeneity
- Prompt students (repeatedly) to sit in a formation conducive to group discussion