What physics education research tells us about teaching physics

A LECTURE ABOUT AVOIDING TRADITIONAL LECTURE STYLE WHEN TEACHING PHYSICS

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Acknowledgements

- Not my research, the work of many others
- Much of what I know I learned from Carl Wieman

It about learning concepts

- Not just rote “plug in the numbers” problem solving
- Physics not just algebra
- Even many students doing well on standard tests do poorly on conceptual questions

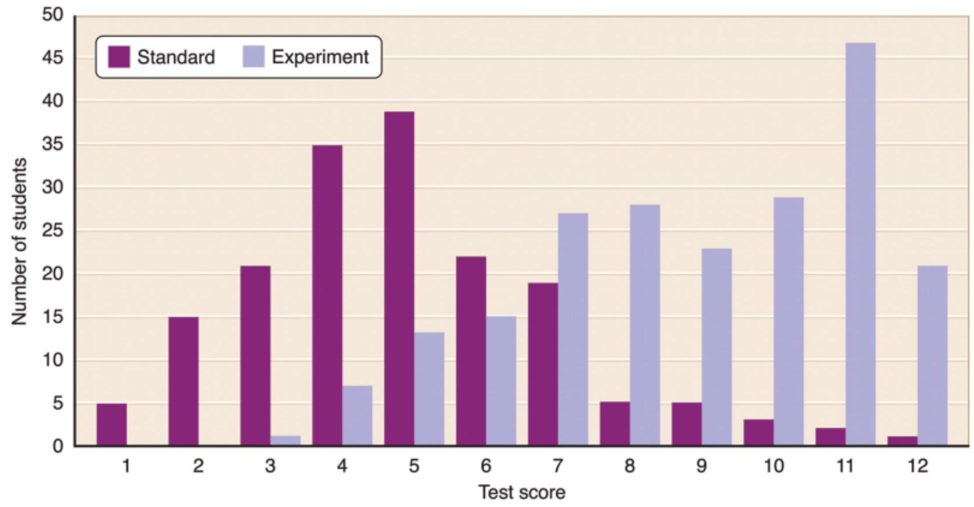
Many Experiments show similar results

Figure from

Weiman and Gilbert

Test of concepts

FIGURE 3



Test scores for students taught an introductory physics module using standard instruction vs. students taught using interactive engagement techniques. Random guessing would produce a score of 3. (Adapted from L. Deslauriers et al., Science 332:862–864, 2011.)

Talk to someone else
2 mins

- Experimental = active learning
- What does this data tell us?
- Which students did better in experimental class?

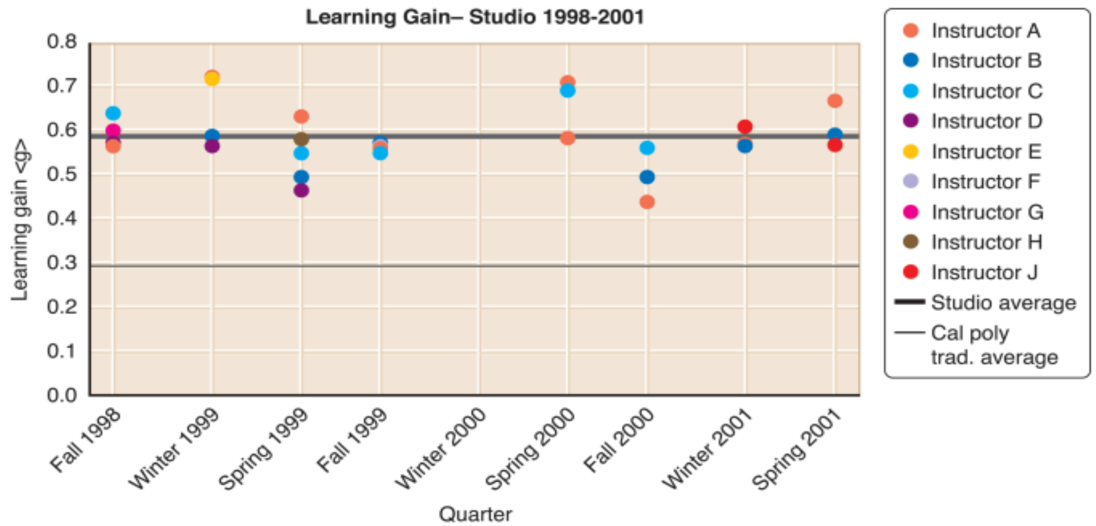
Similar impacts with many instructors

Concept gain (averages)

traditional lecture 0.3

Interactive classes 0.6

FIGURE 1



Learning gains on concept inventory for introductory physics course sections taught by 9 instructors who switched from traditional lecture instruction (avg. gain 0.3) to an interactive method (avg. gain 0.6). (Adapted from Hoellwarth, C., and M. J. Moelter. 2011. The implications of a robust curriculum in introductory mechanics. Am. J. Phys. 79:540–545.)

Key to this effect

- Active learning not passive listening in class ("flipped classroom")
- Small groups of students working together on conceptually challenging tasks
- New Material presented outside class time

Best teaching is Facilitating Learning

- Think carefully about your learning goals for the students

  (course as a whole and class by class)

- Design tasks that engage students in working with the concepts to be learned

- Design homework as learning time not practice time
- Use class time as practice time

Many strategies and teaching techniques

- Start with small changes, work up to fully flipped approach
- Move responsibility for learning new material to students prior to class
- Use class for interactive work that applies the new learning
- Guide by questioning and/or commenting strategically
- Have groups display and share their thinking

example:
Video "lecture" in segments

- You can revise, reuse, improve technique by watching your own videos
- Can incorporate graphics that go beyond your blackboard diagrams
- Some "talk" segments may be replaced by simulations etc.
- Students often review parts multiple times, can go back as needed
- Begin class with concept question to be answered by students

Discussion time (1 min to think first) Pair talk in turns: 2 mins each

- In your own learning what did you do outside lectures to master the material?
- Did the labs help?
- Did working problems with others help?
- Who did you go to for help when you were stuck?

Scientific and Engineering Practices (K-12 definitions)

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting (complex) data
5. Using mathematics and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Asking questions as a scientist

- Not just to find out what someone else knows
- Initial questions –to sharpen initial ideas and observations and begin to define a model for the system under study
- Quantitative questions – to add measured quantities to modeling
- Testable questions –to test model (or theory) and refine them

(the classic scientific method)

Developing and Using Models

- Student's own description of (ie model for) the system under study
- Making thinking visible and explicit is the first step to conceptual change
- Approximations and idealizations can be made more explicit
- Discussion of limitations of the model provokes thinking about key concepts

Planning and carrying out investigations

Analyzing and interpreting data

- Why?
- To test your own model or explanation
- To test a claim made by others
- To learn techniques and strategies

Make “lab” work as an integral part of the learning

- Avoid “cookbook” labs
  – designed to “demonstrate” known relationships
- More learning when students must struggle with interpretation of data that does not fit the idealized equation they have been given
- Analyzing and interpreting complex data from others provide different learning opportunities than analyzing the limited data collected in a lab class
- “lab reports” are rarely meaningful science writing

Developing explanations
Arguing from evidence

- Explain phenomena using known theory

  (only in grad school do students begin to develop new theory)

- Provide model and evidence base support for claims

- Recognize when evidence refutes a claim

Evaluating information

- Information resources are readily accessed
- How do students know which to trust?
- How did you develop your own judgement on that?

Communicating information

- Scientific communication is a learned skill
- When do we begin to teach it?
- Note: one of the skills most demanded by employers

Barriers to change

- Working with large class sizes
  -- use teaching or learning assistants differently

- Initial load of preparation time for video lectures

- Course structure with labs courses separated

- Administrative barriers (or supports that are lacking)