

Harvard Fall Teaching Conference, 30 August 2012
Choosing Problems to Teach, and Teaching Them

Nick Hutzler, *Departmental Teaching Fellow in Physics*
Dr. Lynne Mullen, *Preceptor in the Life Sciences*

Here is a collection of thoughts that we came up with when discussing these options.

How much should it relate to homework/lecture materials/problems?

- Definitely expand on ideas from lecture, but try not to introduce any unrelated material
- A problem with same setup/concept/result/etc. can help reinforce ideas, but make sure that something in it is new.
- Don't simply repeat a problem from lecture with different values
 - This matrix → that matrix, this genetic trait → that genetic trait, etc.
 - This may not help to reinforce concepts if just repeated on its own; either the students got it the first time, or they will still have the same problems
 - Exception - if a PART of a problem is very similar to a PART of a problem done in class, that is excellent! The student can now see the problem in a new light.
- If there is some concept that they have already seen, try to turn it on its head - change it so that one key concept is different and ask the students

What level of difficulty, computational complexity, etc?

- Don't - "This isn't very interesting, but they need to learn it"
- Do - "By itself this isn't very interesting, but they need to learn it, so I will make it interesting"
 - Can this boring technique/idea/etc. be used to derive an interesting result?
 - Example: using matrix diagonalization (BORING) to derive a formula for the N^{th} Fibonacci number (NEAT!)
- Don't - Make simplifying assumptions without justification
 - "Consider a massless pulley..."
- Do - Justify simplifying assumptions
 - "We say the pulley is massless because we haven't yet learned how to study massive rotating objects, but when we do, we will see that as long as the mass of the pulley is much smaller than the mass of the blocks, the problem will be largely unaffected."
 - This will help build intuition
 - Caution - This is tricky, and can get out of hand. If you end up talking about a complex and unrelated topic, such as excitations of the quantum vacuum to justify neglecting wind resistance, you have gone too far.
- Don't make the problem format too different from what they will see on problem sets and exams
 - E.g., no multiple choice questions if they are not going to see them in the rest of class.
- Computational or conceptual?
 - See handout about expanding problems into components, which include both computational and conceptual sub-parts
 - The best problems have both simultaneously (i.e. different sub-parts), though this is not always possible.

- You want to emphasize higher-level thinking, so you can create a few questions involving rote memorization, but try to have more that ask them to apply knowledge that they have learned, analyze data, compare and contrast concepts, etc.

How much to work out yourself?

- For an introductory level course, especially for non-specialists, giving the students ample time to think on their own or in small groups (or other forms of active learning) is crucial.
 - If students are silent, give them 10 seconds before re-phrasing the question. They need time to think and time to decide if they are going to be the one who speaks up.
 - If they still look lost, ask them what they find confusing.
- For an advanced course, there should definitely be more of a focus on solving difficult computational problems.
- Conceptual problems
 - Definitely give the students time to come up with an answer, even for a very advanced course (and don't forget to give conceptual questions!)
 - Simulations, such as UC Boulder's PhET system, can definitely help students understand conceptual problems, and include university level topics.
- Computational problems
 - For simple problems, you may consider giving the students time to work it out themselves, with a group, etc.
 - For complex problems (requiring more than a few minutes to solve), have the students indicate which major steps to take, especially how to get started. If you give them a few minutes to solve the problem they won't get anywhere; if you give them more than a few minutes, you will not be able to get through many problems, and students who are just plain stuck will be sitting there for too long.
- Always, regardless of type of class, level of difficulty, etc. present a complete answer at some point
 - It can be in a future section or in an email after section or class, but do it at some point!
 - Don't assume that because one (or several) students indicated that they knew the answer then you don't have to go over the solution. Always repeat the correct answer so that students who couldn't hear the student speak or were distracted can hear the answer.
 - For a computational problem, make sure the complete solution has been written out on the board and ask students permission before erasing any part of the solution.

Prep Work

- Work out the solutions, in full, to your problems in advance
 - Be prepared to explain in the answer or steps to get the answer several different ways--sometimes an answer will not make sense to students, so you might have to explain the approach in a different way.
- Come prepared with questions to ask the students to help guide them through the problem
 - How should we start the problem?
 - Why did we make that assumption, and why is it valid?
 - What is the physical/mathematical meaning of this quantity?

- If you get stuck, wonder about something, etc. while working out the problem, work that into your section!
 - Stop where you got stuck and ask how to proceed
 - Ask the question you were wondering about
- Have the problems typed up in a handout (for some classes, preceptors will provide you with the section questions and answer keys)
 - The students can now **think** while you are setting up the problem, and not be writing these things down. Lose them during the setup and you will waste valuable time trying to recover.
 - Unless the answer will give away the entire problem, include that as well. That way, when the students are going over the material later on, they can be sure that they have the correct answer!
- Break up the problems into step-by-step, and clearly indicate the solution and transition for each part.
 - If a student gets lost, they can at least recover by the next part.
- Do not panic if students tell you that you are wrong while you are explaining the answer! If you are well-prepared, you will usually provide the correct answer and explanation. Turn this into a “teachable moment”, where you can explain why the student has the incorrect answer.
 - If this happens make it very clear to the other students what has just happened, and why your answer is correct.
 - If you did make an error, tell your students. As painful as it may seem, it's better that they feel they can trust you (and get the right answer) than to salvage your ego. Remember: “To err is human.....”
 - If you find yourself completely stuck and unable to answer the question, don't panic! Tell the students that you will think about the solution, and then report back by email, next section, etc.

Resources for finding good problems, and other help?

- Other textbooks, especially those with a solution guide
- Books full of problems (for example, “A Guide To Physics Problems” by Cahn and Nadgorny, ISBN 0306484005)
- Get ideas from your thesis. This has the added bonus of allowing you to relate a problem to current/recent research.
- Bok Center! Contact your departmental TF, head TF, preceptor, Bok Center staff member, teaching consultants, etc. We are here to help with anything at all.
 - <http://bokcenter.harvard.edu> → “Resources and Advice”

