Homework Problems and Problems with Homework

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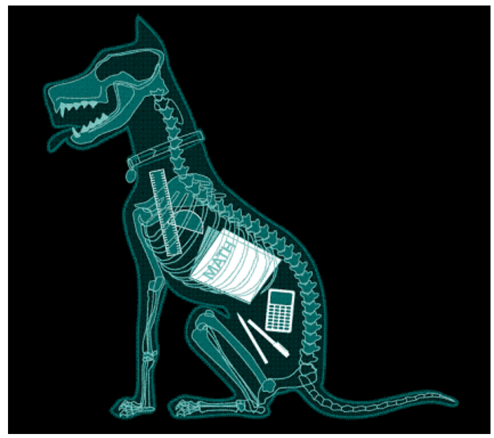
Homework is healthy, nourishing work that should be done - at home. It is the vital reinforcement of the day's hard earned insights. But mostly it's the missing link in our students' educational evolution. Let's try to understand the homework problem and push our students to a new level of physics understanding.

The Homework Problem

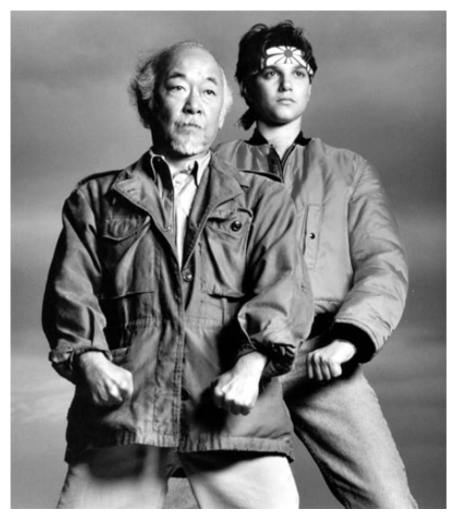
Each year I used to discover anew, somehow to my surprise, that my students hardly ever did their homework. Class after class I would feel the same existential despair while vainly asking who would like a question taken up. I squandered much class time demonstrating how well I could solve physics problems for the handful of kids who actually tried them. In the end, so I thought, the students must sink or swim. If they're not getting their homework done and benefit from my learned (nay, inspired!) solutions, it's their own darn fault.



Fortunately I have calmed down since those days and reassessed this problem. My physics students, though attending an academic, high-achieving school, still need considerable hand holding and support in developing good learning skills. In many cases Gr. 12 is too early to be taking off the training wheels in service of the sink or swim mentality. If I let them they would wing it until they can't manage anymore and then, being so far behind, simply fail. Implicit in the sink or swim mindset is the belief that it is either acceptable or at least understandable that only a small fraction of our students ever learn physics well. I don't think I need to argue that this mindset has no place in the 21st century.

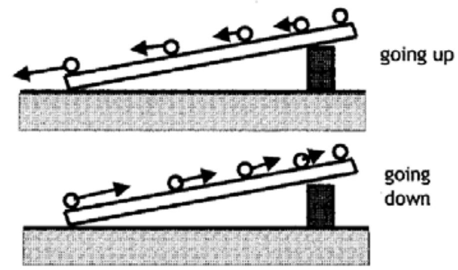
My Homework Solution

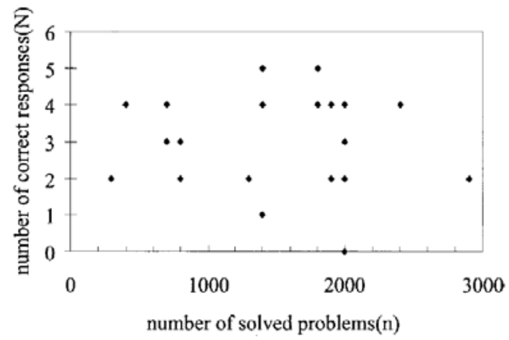
My solution is a fairly regimented homework routine. The hope is that when they get to university and the training wheels are snapped off, they will have passable skills to fall back on – skills which they had little choice but to develop. In my course homework assignments are an important part of their mark. I check homework randomly and it is worth very little unless it is done my way. The first missed check or two is painful, but can easily be recovered from. And here is the deal, just like the one between Mr. Miagi and Danielson: paint the fence (try to imagine his voice), sand the floor, wax the car and you will become a physics/karate master (last semester my median student scored 87% on the FCI where 85% is recognized as Newtonian mastery). My way is certainly more work, in fact an order of magnitude more compared with the scratches that usually get passed off as homework, but I try to strike a balance.



More Just Means More

Learning does not take place when work is done thoughtlessly. This is an important point from the much abused 10 000 hour expert theory (good theory, bad people who quote it without having read the original research). Only deliberate practice under expert guidance can help one to become an expert. I can recall a sullen student who explained to me how she did every problem in the chapter review and still managed to disappoint on the test. I have trained physics teachers who have had a very traditional, rote education and who have surprising difficulty explaining basic concepts. This also explains why after 30 years I still type slowly on the computer using two fingers. In Korea, students often go to bonus school after their regular school to get extra practice with their physics problems. Results show that this "practice" provided no measureable gain on simple, conceptual questions. One such question is shown to the right where a student was asked to draw acceleration vectors for an object on an incline. The graph showing the correlation between number of practice questions solved and success on simple conceptual questions has scattershot that would even embarrass Dick Cheney. So much for those 10 000 hours.

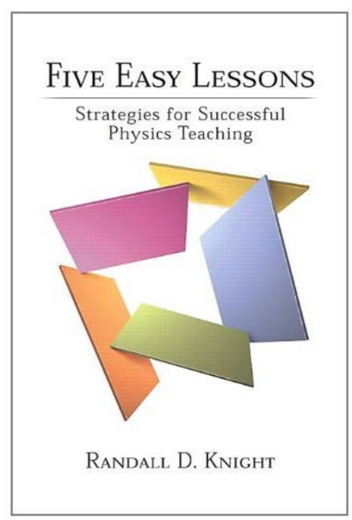




Do Less, Really, Really Well

To make room for more thoughtful homework practice, I have curbed my reflexive habit to assign questions 1 – 7 at the end of each day's section in the text. Instead, I choose just a couple of decent, somewhat insightful questions and expect them to be done well. To help my students do their work in a thoughtful manner, I provide them with a solution sheet (blank, model, sample) that emphasizes multiple representations. Students have a much better chance of developing a deeper, more nuanced understanding of physics if they can explain a situation from a number of different physics angles using a variety of tools. Even the College Board of AP Physics fame has caught on to the value of multiple representations – which means this is well overdue.

My own solution sheets are modeled after those presented in Randall Knight's fine tome *Five Easy Lessons*. To get credit for their homework, my students must solve their problems according to this format. The amount of detail and thinking that goes into one solution, even for a lackluster textbook question, becomes impressive. A crucial benefit of multiple representations that is it allows students to begin to think about self-consistency. Does the force diagram agree with the position graph? Do the events labeled in the sketch coincide with the right moments in the motion diagram? This is an instinctive process for many experts but is seldom ever practiced by novices. Another benefit is how abstract equations become more meaningful. Students learn to see in many ways what those odd symbols and numbers represent. My tests and quizzes follow up on this new process asking for particular parts of the solution or the full monty (do you really want to click on this link?) Notice that I don't ask students to memorize the detailed procedure - that's not the point. I reproduce the solution outline on their tests and quiz pages and instruct them to use the headings as a checklist. The headings are also great for quick feedback as well.



The (try to be delicate) Inadequacies of Textbook Problems

I get really frothy and shout at my computer a lot when I review textbooks – I'm glad the cat is my only witness. When I reach the practice questions I usually go bonkers. What should be a lively slice of the wide and wonderful world of physics is somehow all about boxes – talk about thinking inside the box. Then there are all those "plug and chug" questions. Students need surprisingly little practice with their math (you heard me, surprisingly little – but that's for a whole other article). What they really need is lots of practice thinking, testing, applying, extending, explaining, judging, planning and a few other quality "ings". There is remarkably little latitude for thought in a typical textbook question. It is usually obvious which single equation is to be used and which quantities should be plugged in.

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Standard questions seldom draw upon a range of physics within one problem – even the chapter-spanning unit review questions. These uninspired problems cement the compartmentalization of student's physics knowledge. Force problems are only about force, graphs of motion disappear right after kinematics ends, and other topics like sound, electricity and energy are scattered around students' minds like disembodied limbs after the walking dead have been through town.

How a Student Interprets a Typical Textbook Question

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is montilled in Ceristanna. The Ceristannians gristeriate large amounts of fevon and then bracter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future because of our zionter lescelidge. Answer the following questions in complete sentences. Be sure to use your best handwriting.
1. What is traxoline?
2. Where is traxoline montilled?
3. How is traxoline quaselled?
4. Why is it important to know about traxoline?

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Real Problems for Real Students

Good questions are rich in context and read much more like stories. They are plausible situations presented in casual language and do not ask students to solve for "*x*". Multiple steps require the student to form a clear picture of the problem and develop some thoughtful planning. A typical student can't look at a good question and say, "I know how to solve this". Instead they say, "hmmmm… I have to work this out". That is exactly when they start to build the skills we are looking for. I'm not sure I saw a single question of this caliber in the last textbook review cycle. Pioneering work into context-rich problems has been done by Pat and Ken Heller at the University of Minnesota and I highly recommend their extensive online resources. I try to provide some additional nuanced questions for my students, but I have only so much time. The solution process I have described helps add vitamins (or steroids - but I won't be caught like Lance) to the more typical textbook problem.

My Challenge to You

Try this out. Give a persuasive pitch why high-thinking homework is so valuable. Provide some samples and train your students in the new process. Keep a stack of solution sheets readily available in your class and even put it online if possible. Follow this up in your tests and quizzes. See the difference it makes. You may even smile again at the thought of homework.