

Memo to the Faculty

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Engage all your students with “challenge problems”

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As every instructor knows, probably the most difficult aspect of teaching is dealing with the range of student preparation in a class. I have taught some classes where that range is enormous. What can be easy for some students can be impossibly difficult for others, and conversely, what can be a reasonable level of challenge for some students can be boring and trivial for others. Here I present a solution that has allowed me to have all students engaged and learning the material during the entire class period, even though they come in with vastly different levels of preparation.

ONE APPROACH: GROUP TASKS

One common approach for optimizing the learning for students with a range of preparations is to have group tasks: tasks covering material through questions or problems that students solve in class by working in small groups (ideally 3 students). These typically take the form of challenging conceptual clicker questions with group discussion, or worksheet activities where the group takes 10-30 minutes to solve a more extensive problem and write out the answer.

This group problem solving benefits the students with weaker preparation, because other students in the group can help them fill in gaps, somewhat like having a personal tutor. This allows the students with less preparation to get far more out of the class than they ever could from listening to a lecture that targeted the average student. Although such activities are beneficial to those less prepared students, studies show that the learning gains produced by such group problem solving are usually larger for the better prepared students; a result that will be no surprise to the many teachers who have noticed how much better they understand a subject as the result of teaching it.

MORE EFFECTIVE APPROACH: ADD “CHALLENGE PROBLEMS”

Such in-class group problem-solving and its benefits are well known, but here I discuss a more novel option, the addition of “challenge problems” to these

group tasks.

For a class with a large spread in student preparation, there will be variations in how quickly and easily the various groups complete the task. So one will have the situation in which some groups or individuals are all finished and getting bored and disengaged from the class, while others are still working away very productively. The same happens with clicker questions. A simple solution to this problem that has proven to be surprisingly successful is to add a “challenge problem”.

This is a more difficult problem that is closely related to the primary problem. The challenge problem is labelled as such and given out with the primary problem. Students are told to work on it only after they have finished the primary problem. They do this almost universally with no prompting, and through this process stay interested and engaged well after they completed the original task. The solutions to these challenge problems are not presented in class. If students ask about them, the discussion can be deferred until after class or posted later. All my students have been happy with that.

Here’s an example of a challenge problem from Physics 19, How Things Work: An Introduction to Physics. This was in the unit on heat flow and transformation of energy between different forms. As the problem required students to model a whale and the heat flow in it, then look up the quantities needed to work out a solution, and then perform the calculation, I knew it would take the quite a lot of time (up to ½ hour). So for this case I prepared two challenge problems, and both were needed.

Calculate approximately how many calories per day a blue whale has to eat just to stay warm when it is in arctic waters. Give arguments for why the result you calculate is reasonable. Challenge problem 1. How many calories of food do they have to eat to build up their blubber layer? Challenge problem 2. How many calories of food do they have to eat to swim 20 miles in a day?

This problem was quite successful, in that it kept all the students in the class fully engaged for about half an hour, when class ended, and all completed the primary problem. The rate of progress ranged from one group that was working on the second challenge problem to one group that chose to stay for about 5 minutes after class to complete the first problem.

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